

Real-Time Scenario

Carrie Williams

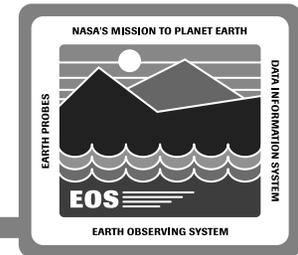
Ken Fregeolle

Tim Holtz

Dave Peters

14 December 1994

Real-Time Scenario



Pre-Contact

- System Initialization
- User Connection
- Command Authority Request
- Ground Script Initialization
- NCC Communications Test
- EDOS Communications Test

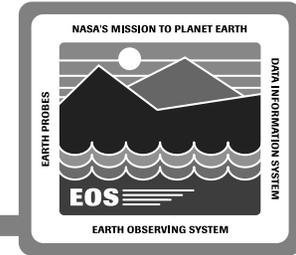
Contact

- Ground Telemetry Processing
- Spacecraft Telemetry Processing
- Spacecraft Commanding

Post-Contact

- Spacecraft Telemetry Playback
- Spacecraft Telemetry Merge
- Statistics Generation

Real-Time Scenario Pre-Contact



Pre-Contact

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- User Connection
- Command Authority Request
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- NCC Communications Test
- EDOS Communications Test

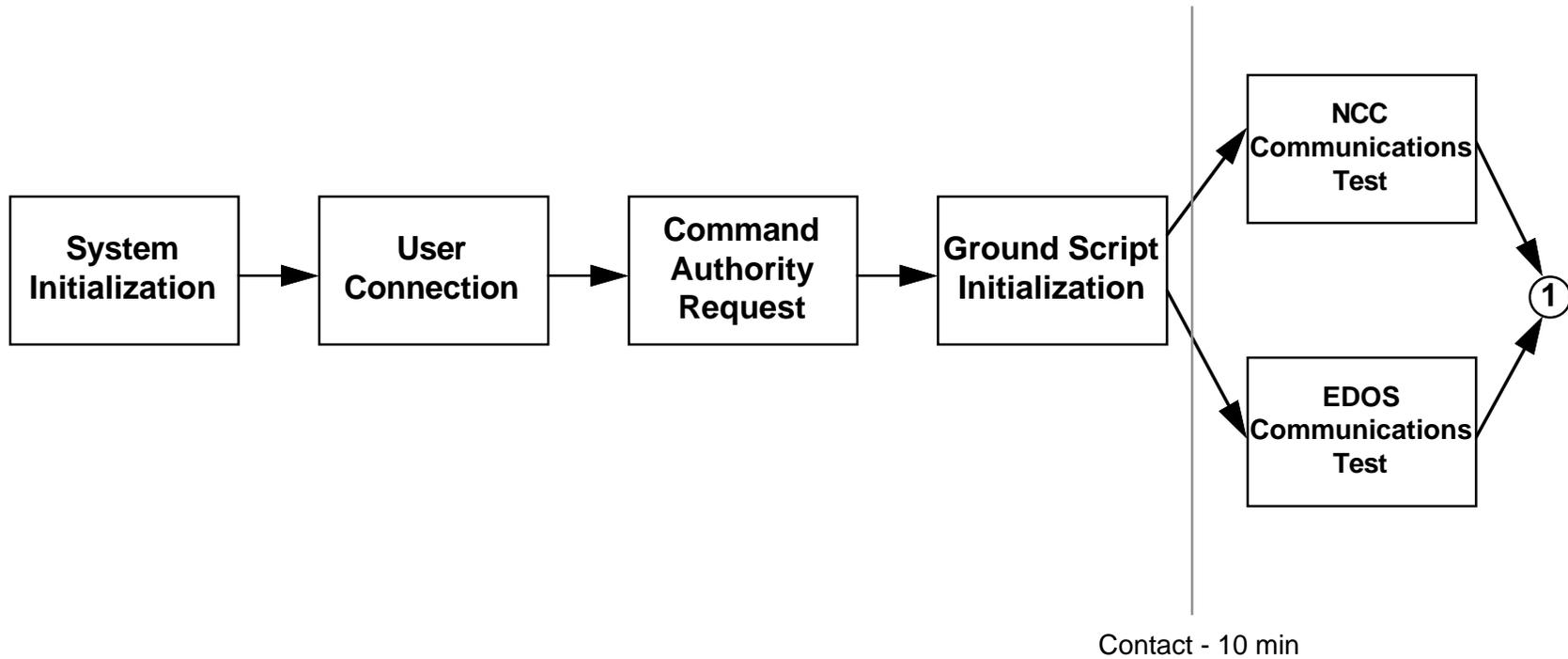
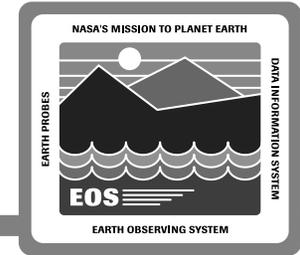
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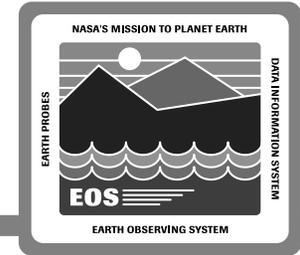
Post-Contact

- Spacecraft Telemetry Playback
- Spacecraft Telemetry Merge
- Statistics Generation

Real-Time Scenario Pre-Contact (cont.)



Real-Time Scenario Pre-Contact Overview



System initialization

- **Creation of logical strings for nominal real-time processing**
- **Additional logical strings may be created dynamically any time after system initialization**
- **Logical strings may be reconfigured as necessary any time after system initialization**

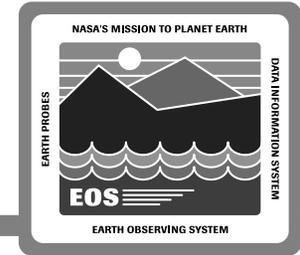
User connection

- **FOT and IST users**
- **Users may connect to one or more strings for configuring and monitoring real-time activities**

Command Authority Request

- **Reserved for selected FOT members only**
- **An FOT user must request and receive command authority**
 - **Prior to configuring the EOC command capability**
 - **Prior to transmitting spacecraft commands**

Real-Time Scenario Pre-Contact Overview (cont.)



Ground Script Initialization

- Nominally a ground script includes an entire day's activities for a given spacecraft
- The ground script is initiated for each new day

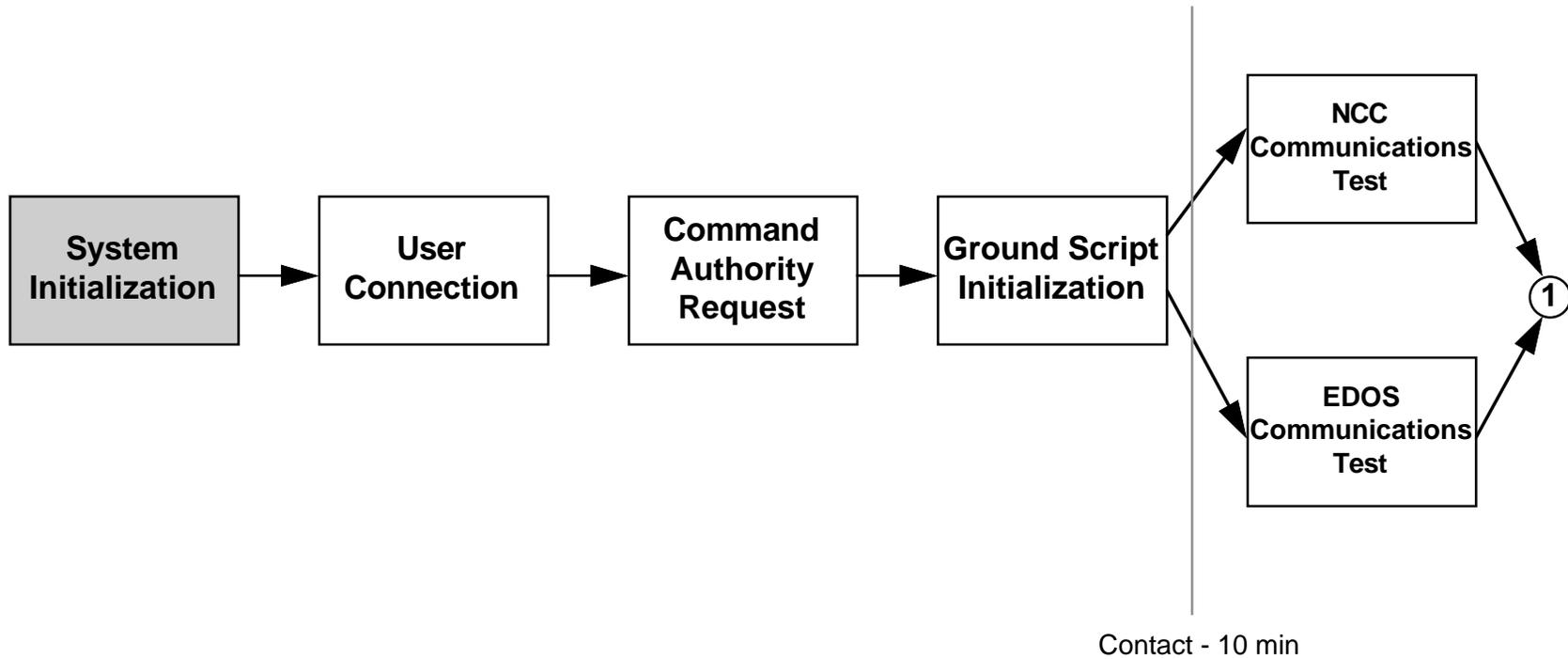
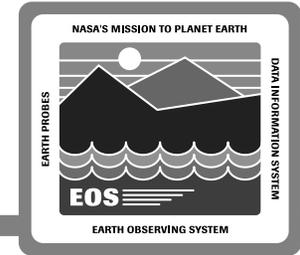
NCC Communications Test

- Tests communications with the NCC prior to a scheduled contact
- Nominally occurs at a pre-determined time prior to the scheduled contact

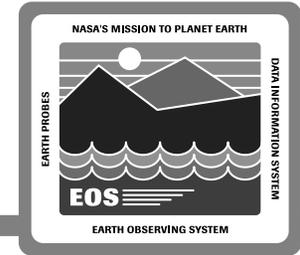
EDOS Communications Test

- Tests communications with EDOS prior to a scheduled contact
- Nominally occurs at a pre-determined time prior to the scheduled contact

System Initialization



System Initialization Description

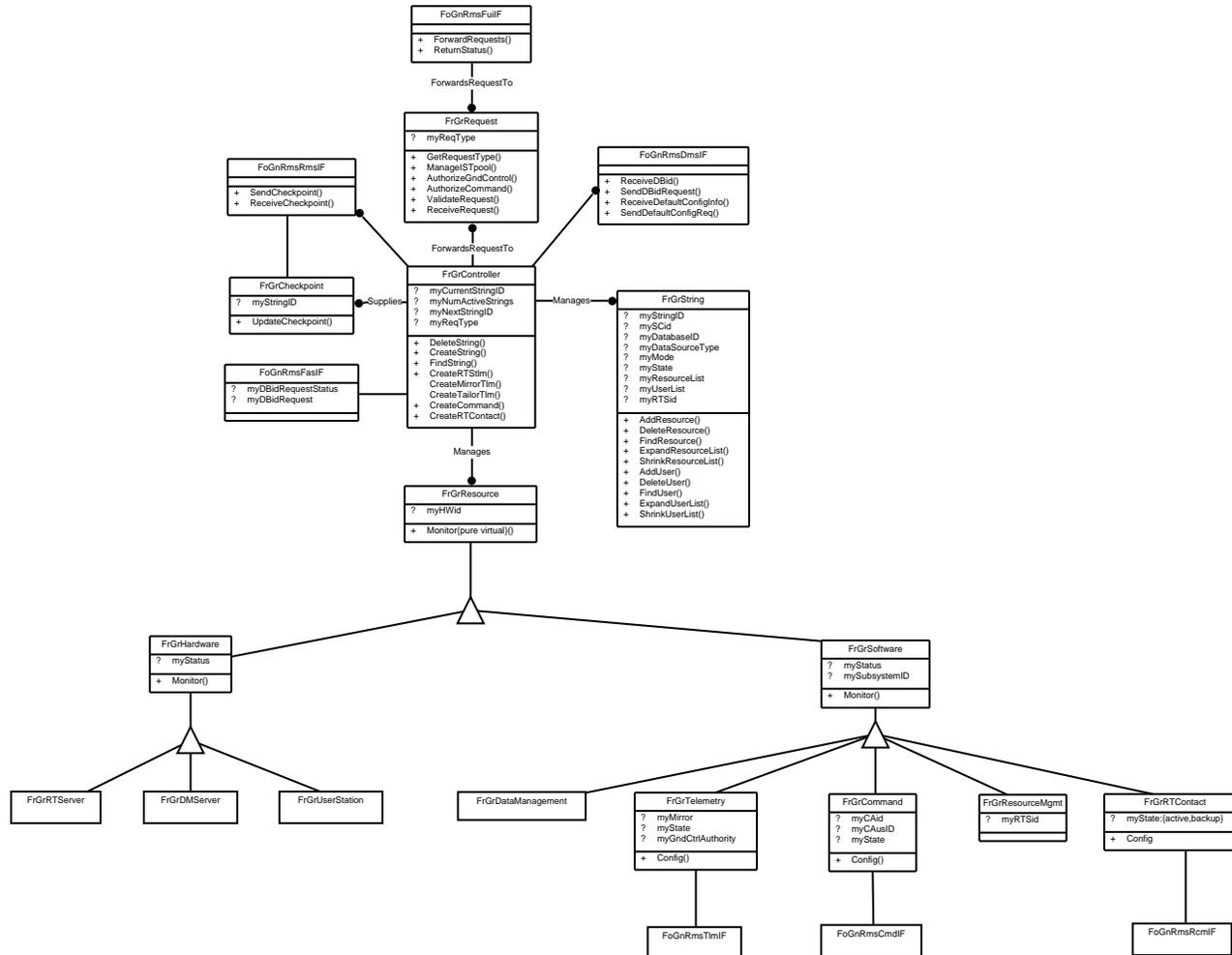
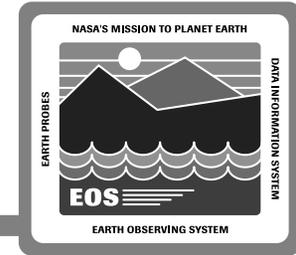


Access and execute default configuration procedure

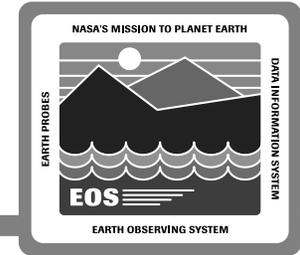
Establish real-time operational logical string, including comprehensive telemetry monitor, for each operational spacecraft

Establish backup logical string for each operational spacecraft

System Initialization Object Diagram



System Initialization Design



Request/receive default configuration procedure from DMS

Request/receive data base id from DMS

Real-Time operational logical string created for each spacecraft

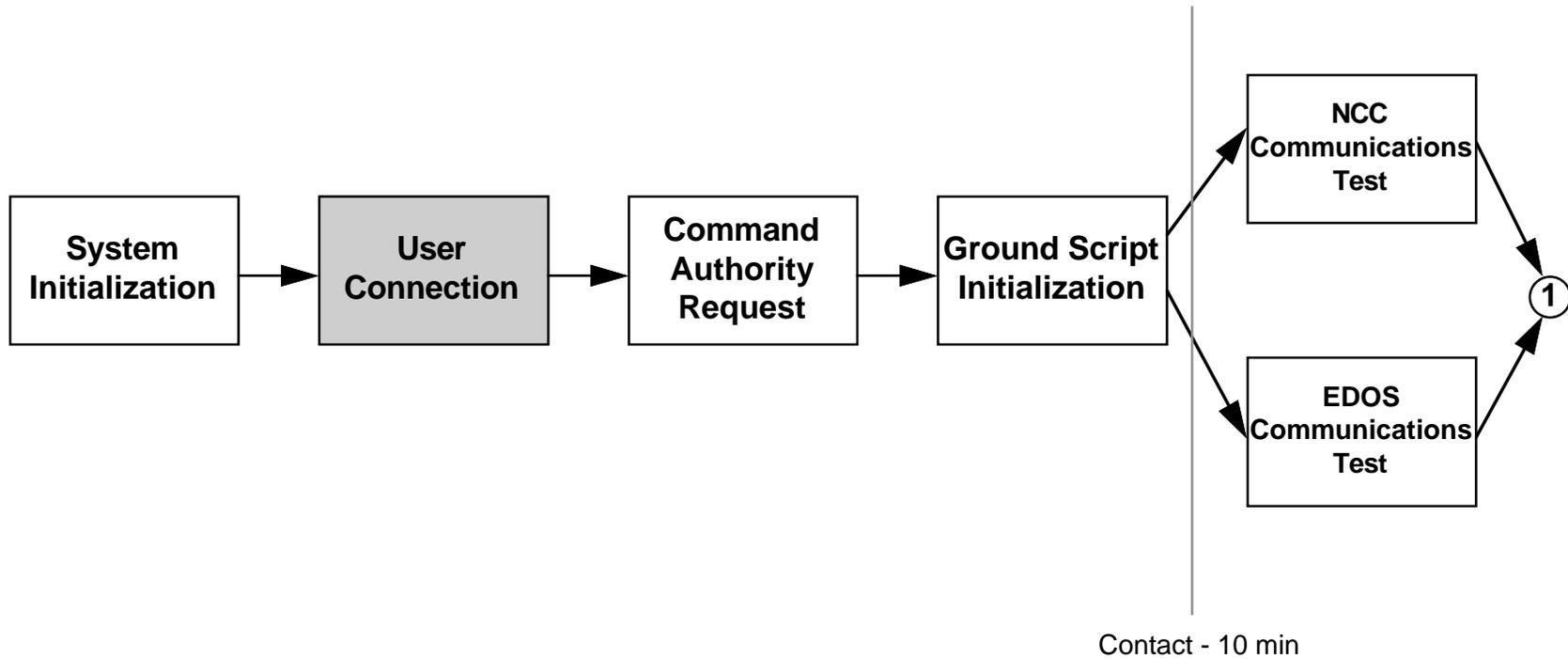
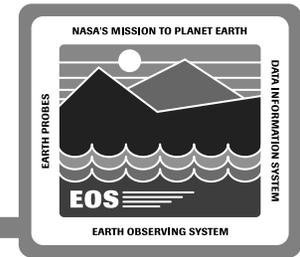
- **Create/Configure Telemetry, Command, and Real-Time Contact Management Subsystems**
- **Add new software resources to resource list**

Backup logical string may be requested for each spacecraft on a different Real-Time Server

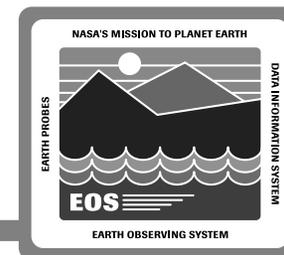
Key Term:

logical string - collection of FOS resources that support shared access to real-time contacts, simulations or replay of historical data

User Connection



User Connection Description

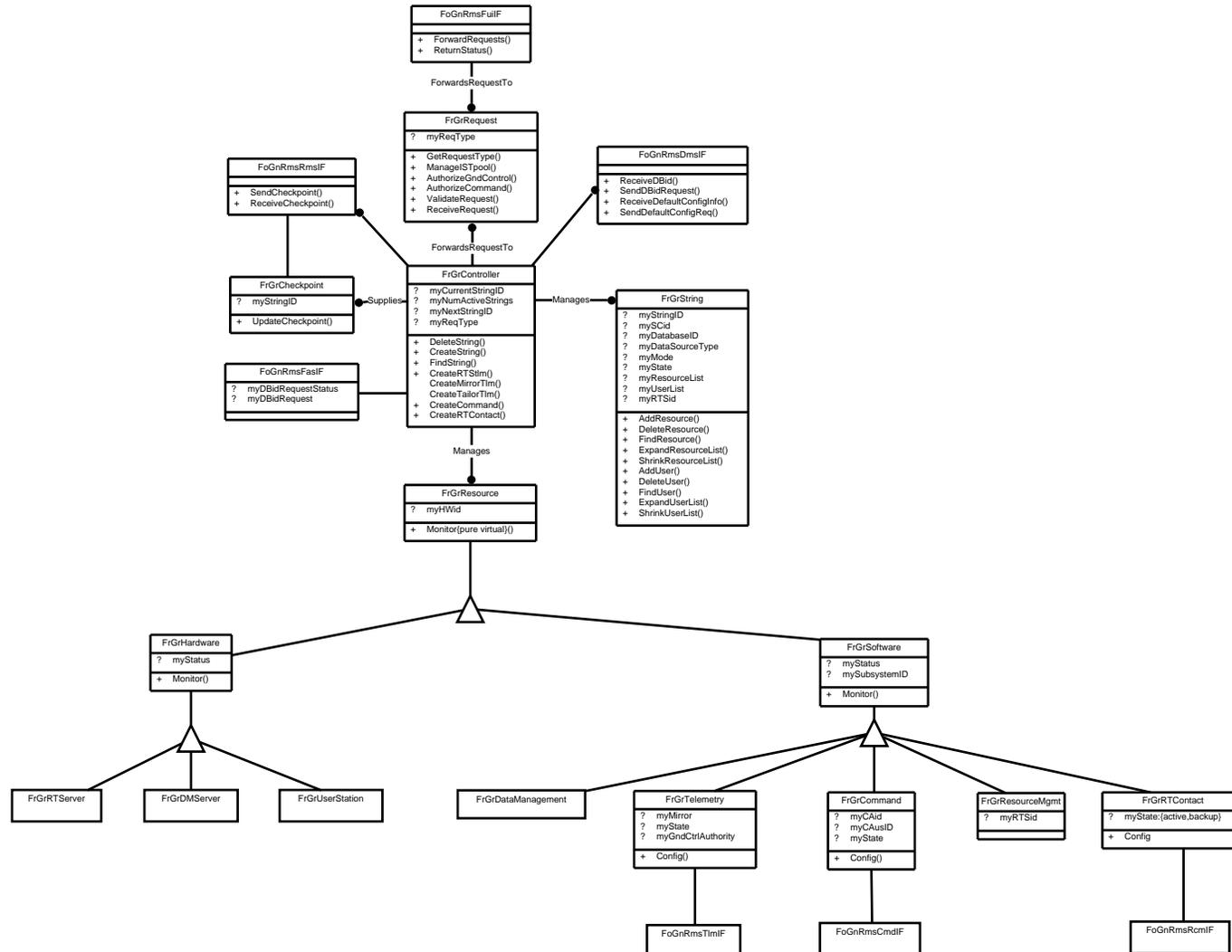
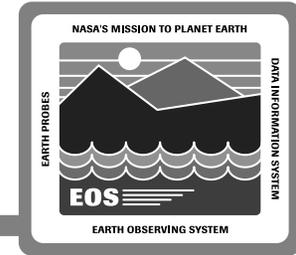


Associate FOT or IST user with established operational logical string

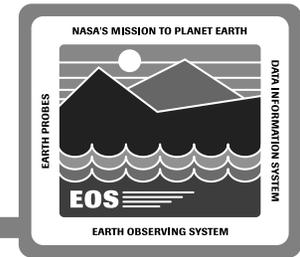
Provide FOT or IST user with local telemetry processing

Provide FOT or IST user with access to telemetry data

User Connection Object Diagram



User Connection Design



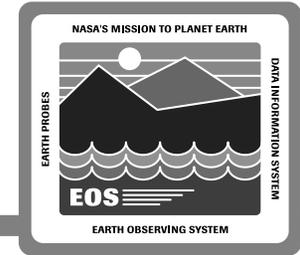
Associate FOT or IST user with established logical string

- Locate logical string that provides user with access to desired resources
- Add new user to logical string user list
- Add new resources to logical string resource list

Provide user with local telemetry processing

- Mirrored telemetry service
- Tailored telemetry service

User Connection Design (cont.)



Provide user with local telemetry processing

- Mirrored telemetry service
 - FOT users
 - Allows user to be actively involved in command and control

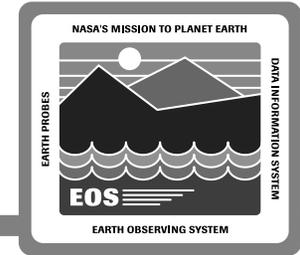
Key Terms:

mirrored telemetry - telemetry software residing on user workstations that provides complete parameter processing with temporary limit definition controlled in parallel with the comprehensive telemetry monitor

comprehensive telemetry monitor - telemetry software residing on the Real-Time Server that provides complete parameter processing with temporary limit definition controlled by user with ground configuration authority

ground configuration authority - privilege granted to one FOT user per logical string to alter the configuration of the comprehensive telemetry monitor

User Connection Design (cont.)



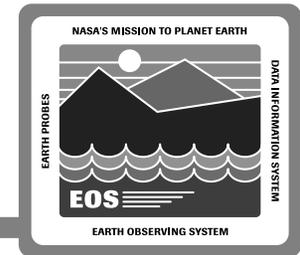
Provide user with local telemetry processing

- Tailored telemetry service
 - IST users
 - Allows users to concentrate resources on individual instruments or the spacecraft
 - Conserves resources on workstation for other tasks

Key Term:

tailored telemetry - telemetry software residing on user workstations that provides selective parameter processing and limit settings controlled by the individual user

User Connection Design (cont.)



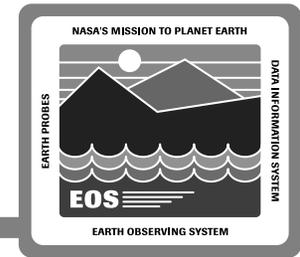
Provide user with access to telemetry data

- Configure local telemetry software with multicast address used by comprehensive telemetry monitor

Key Terms:

multicast - message addressing technique in which data is sent over a network for capture by multiple nodes

User Connection Design Benefits

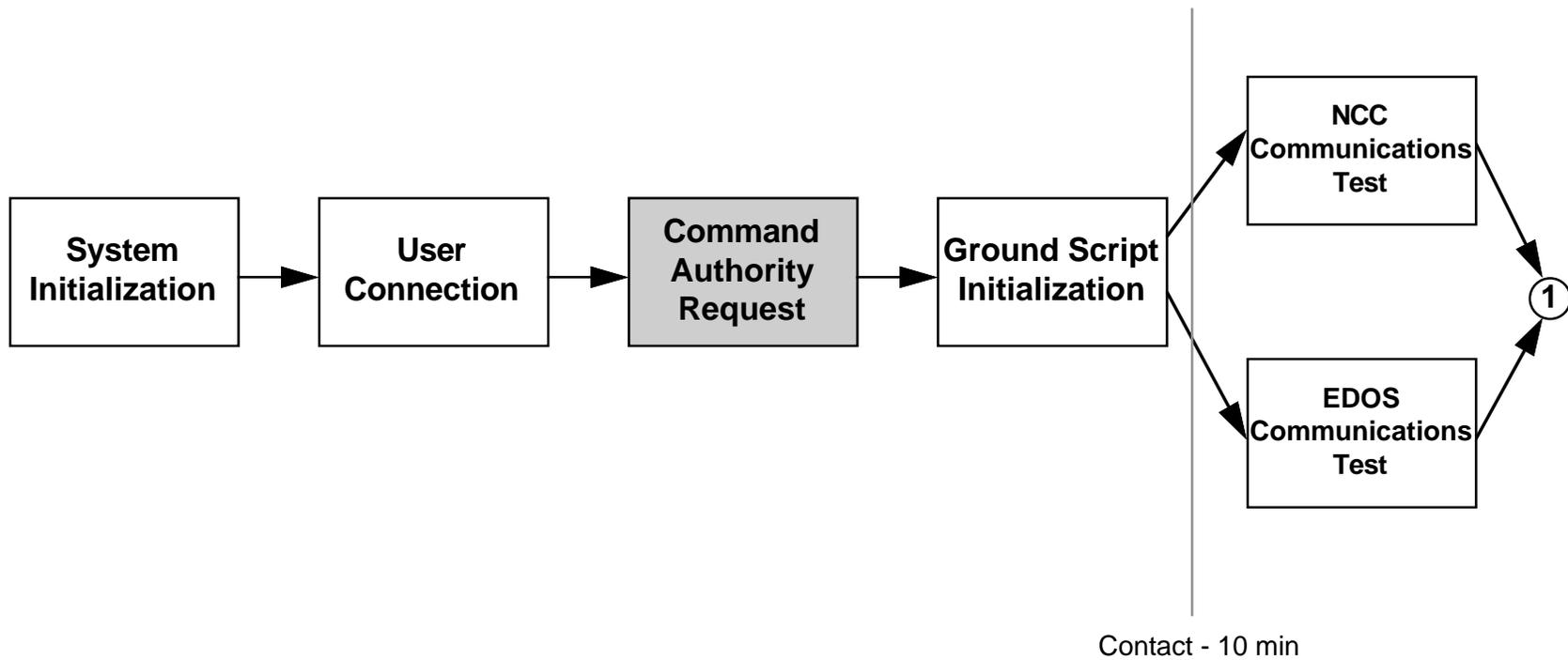
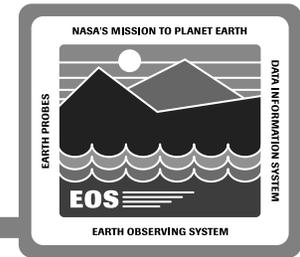


User can monitor data selectively from multiple sources

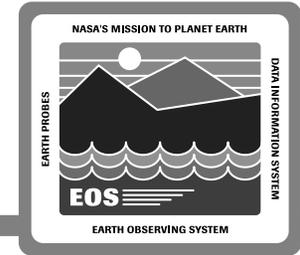
Processor load is lower with tailored telemetry processing than with comprehensive decommutation

Additional FOT and IST users can be accommodated without increasing load on the Real-Time Server

Command Authority Request



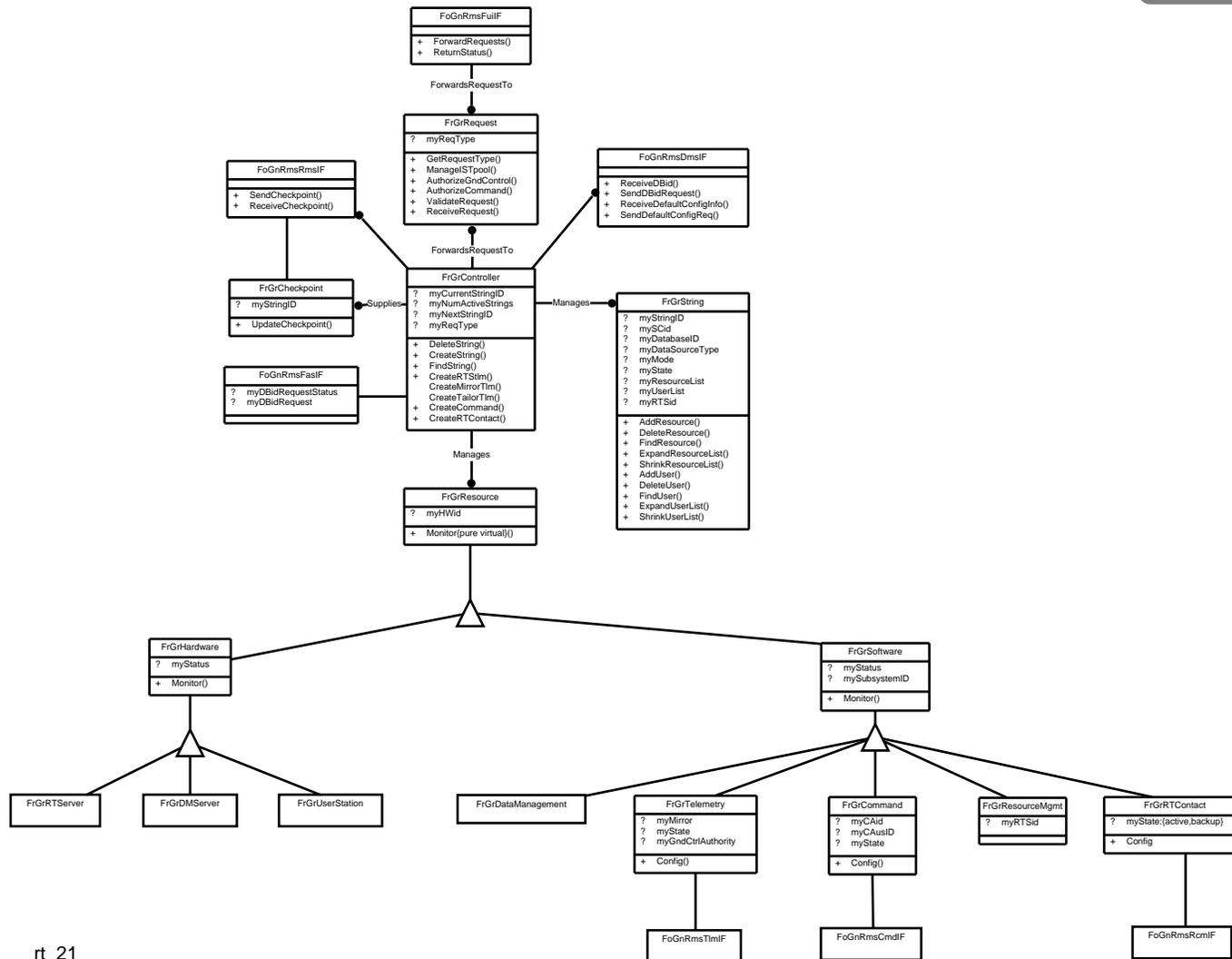
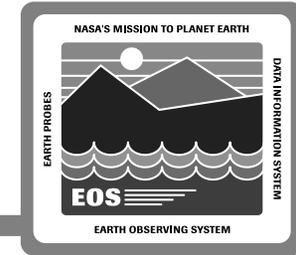
Command Authority Request Description



Command authority provides FOT user with privilege of sending commands to EOS spacecraft

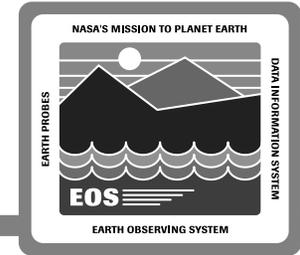
Management of command authority ensures that there is a single point of command for each EOS spacecraft

Command Authority Request Object Diagram



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Command Authority Request Design



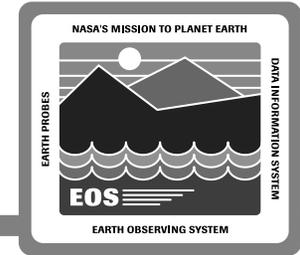
Authorize/Grant request

- Compare user id with list of authorized users
- Compare workstation id with list of EOC workstations
- Authority immediately revoked from previously authorized user
- Authorized users immediately granted authority

Inform Command Subsystem of new command authority

Notify users of new command authority

Command Authority Request Design Benefits



Guarantees that the EOC has a single command authority for a given destination (e.g. AM-1 spacecraft, AM-1 simulator)

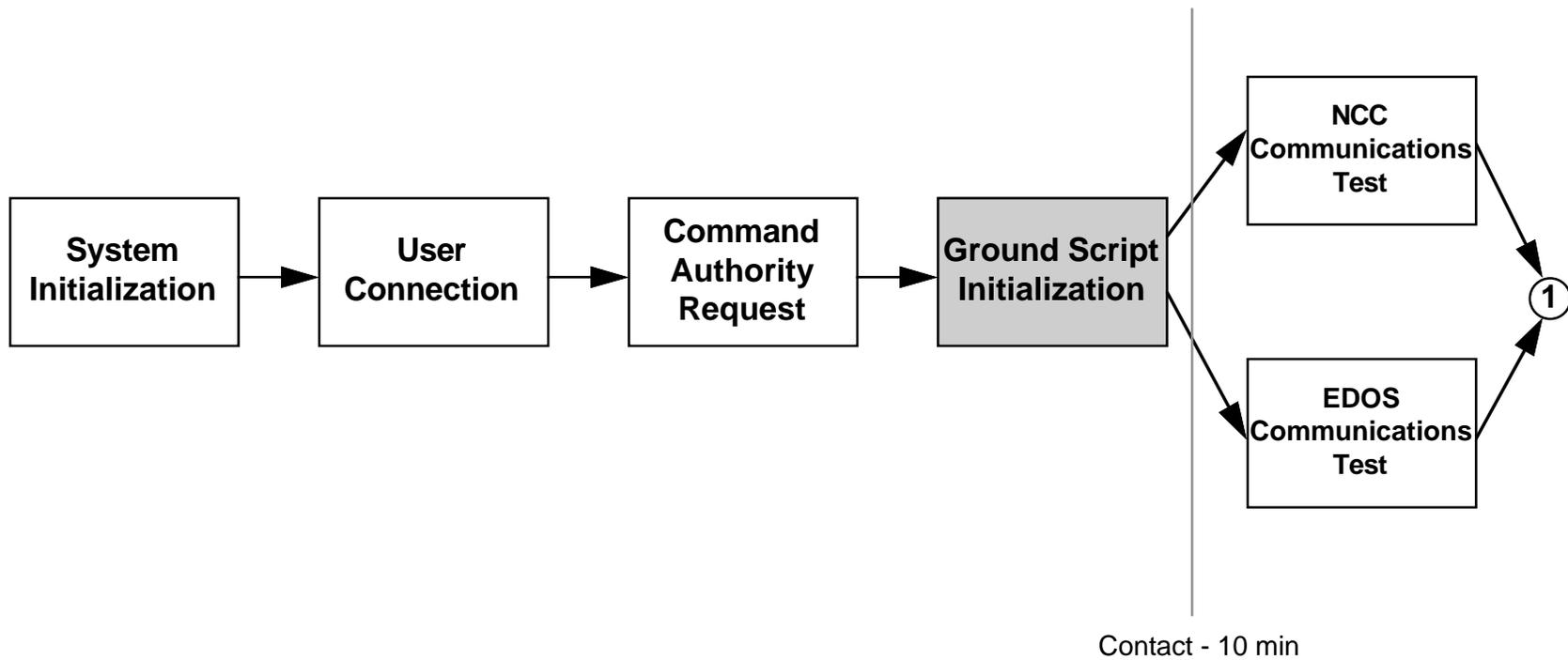
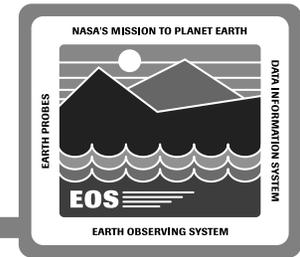
Change in command authority value revokes privilege from one user and grants it to another in one step

In an emergency, privilege is immediately available to the user who needs it

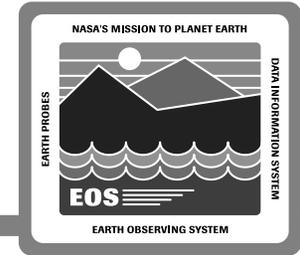
Command authority information stored globally accessible configuration table provides visibility

Allows user workstations and ISTs to be located outside of the EOC while ensuring that spacecraft commands can only be sent from authorized users located inside the EOC

Ground Script Initialization



Ground Script Initialization Description



One active ground script per spacecraft at a time

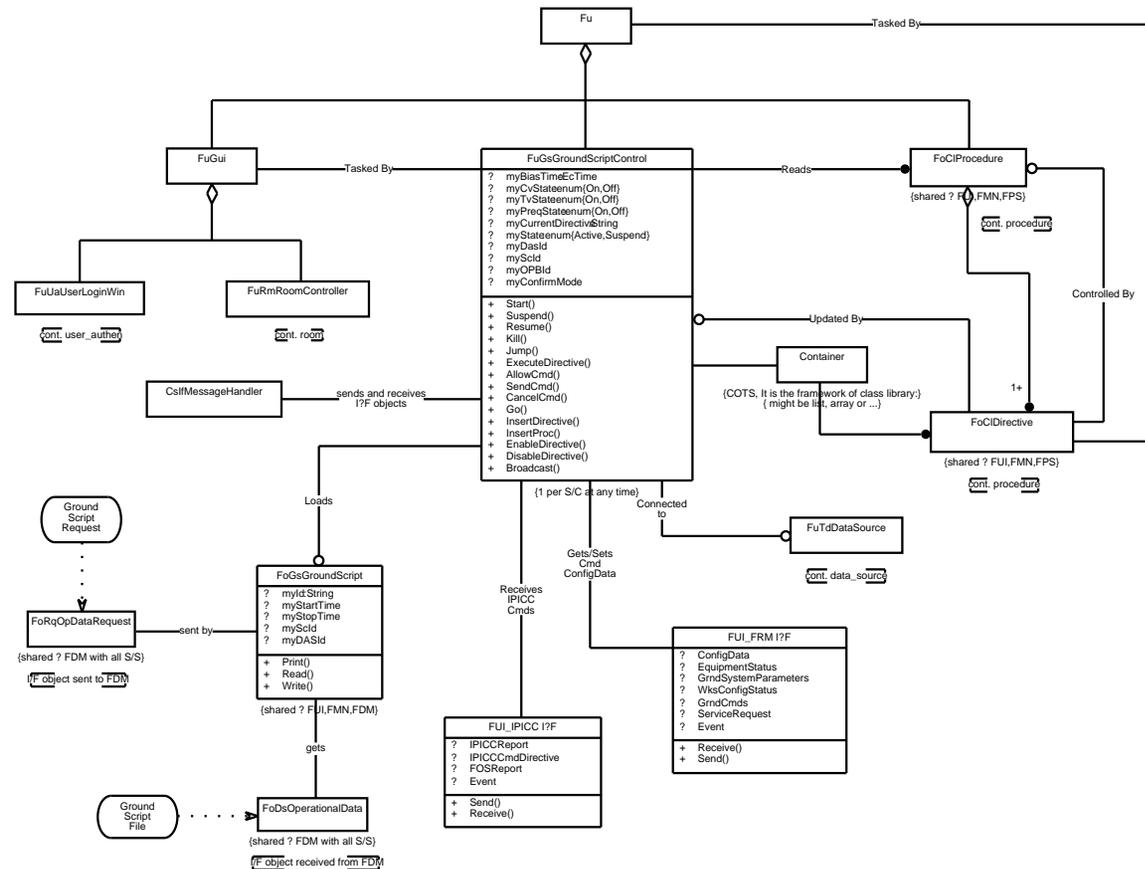
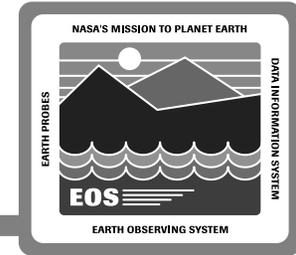
The FOT operator with command authority controls the execution of the ground script

A ground script is created from Detailed Activity Schedule and stored at Data Server 24-48 hours before target day

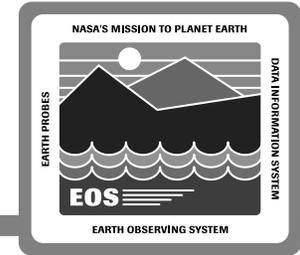
Key Term:

ground script - a collection of time-stamped, time-ordered directives that provides an automated approach to planned activities

Ground Script Initialization Object Model



Ground Script Initialization Design



FOT operator with command authority activates the Command Control Window

FOT operator selects ground script from Ground Script Selector

FOT operator confirms the start of the selected ground script

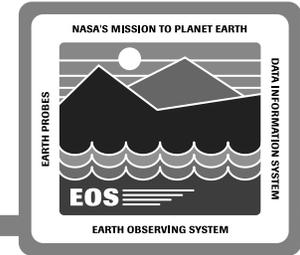
Ground script is loaded from DMS (FoDsOperationalData)

Execution of the ground script via FOT control

Each directive is executed at its scheduled time

FOT and IST users can view command activity via the Command Monitor Window

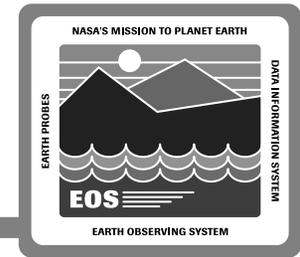
Ground Script Initialization Design Benefits



Provides automated approach to planned activities

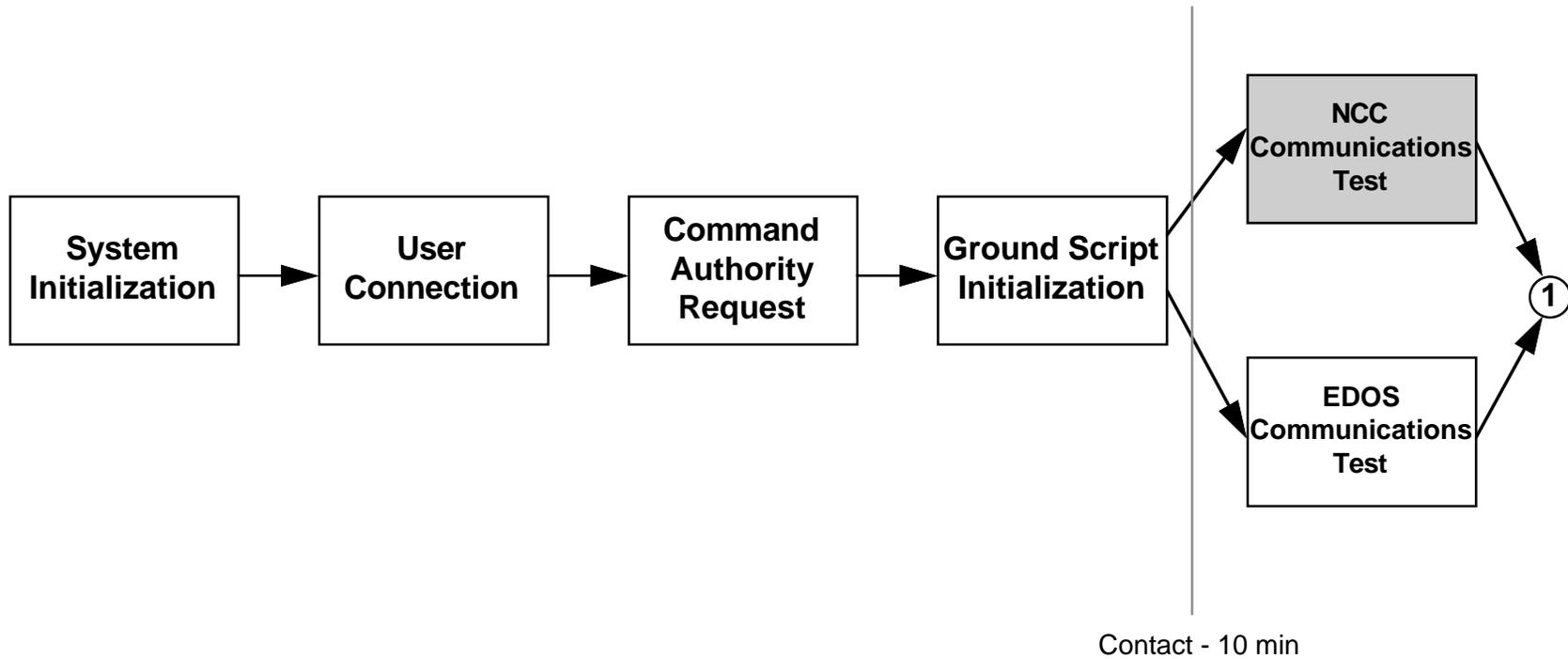
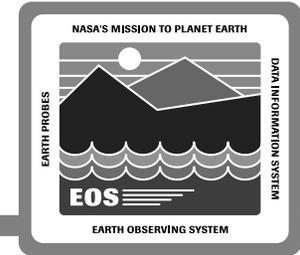
Provides global visibility into spacecraft commanding

Command Control Window

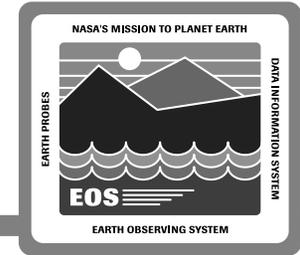


Available in hardcopy only.

NCC Communications Test



NCC Communications Test Description



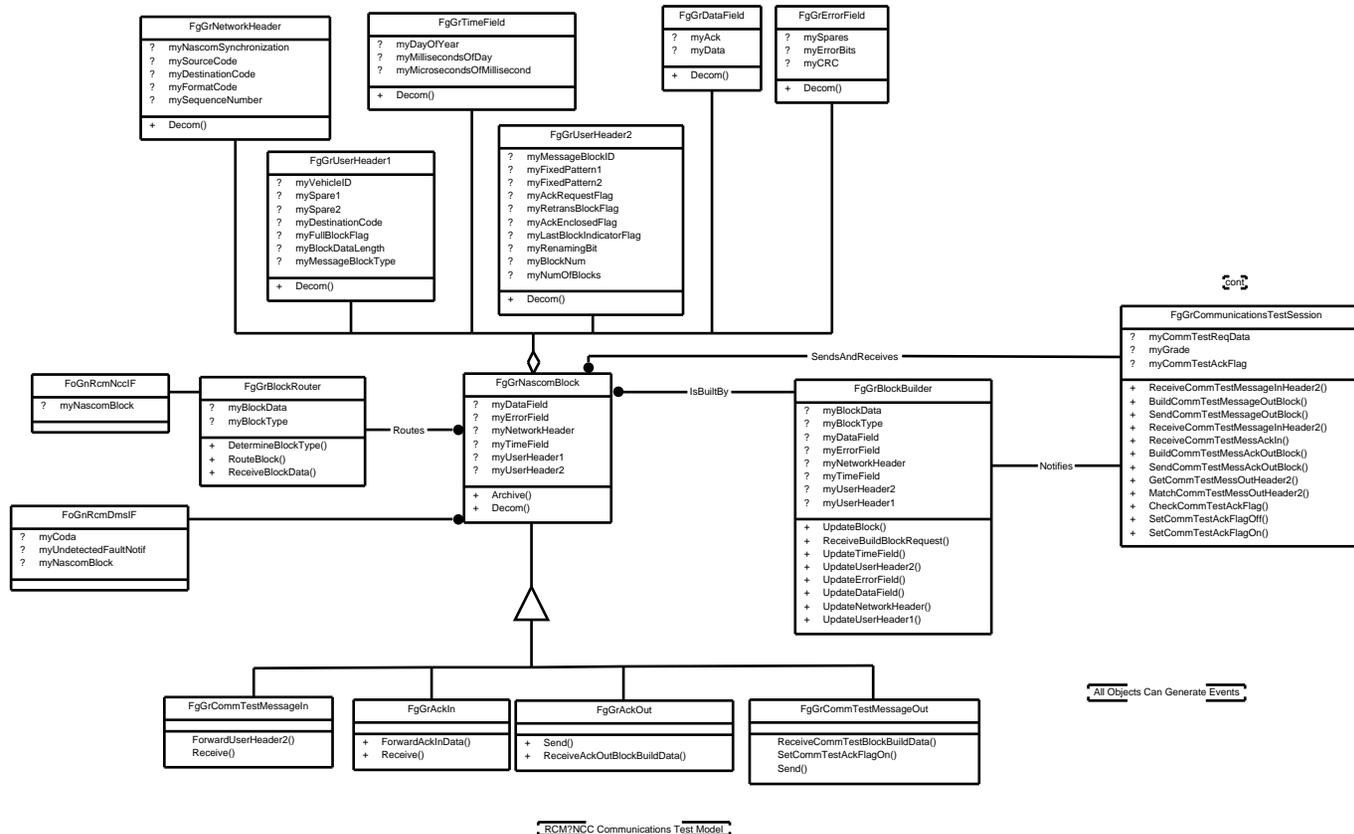
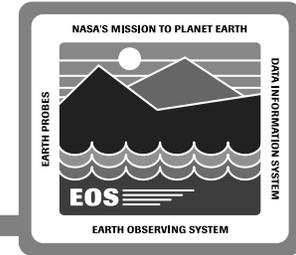
Communications Test messages exchanged with NCC before each spacecraft contact to ascertain the existence of an operational communications link between NCCDS and the FOS

Note:

EDOS prepared to support pre-contact Test messages

Working meeting with EDOS planned

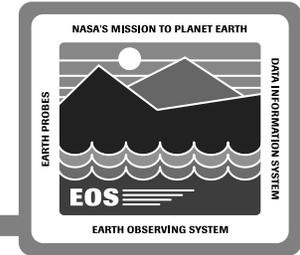
NCC Communications Test Object Diagram



All Objects Can Generate Events

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NCC Communications Test Design



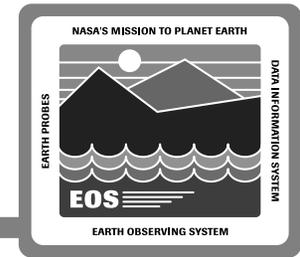
Communications Test message received from NCC

- Acknowledgment of Test message returned immediately

User capable of initiating Communications Test message sent to NCC

- Acknowledgment received within 5 seconds
- Distribute PASS status to user for display

Real-Time Scenario Contact



Pre-Contact

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- User Connection
- Command Authority Request
- Ground Script Initialization
- NCC Communications Test
- EDOS Communications Test

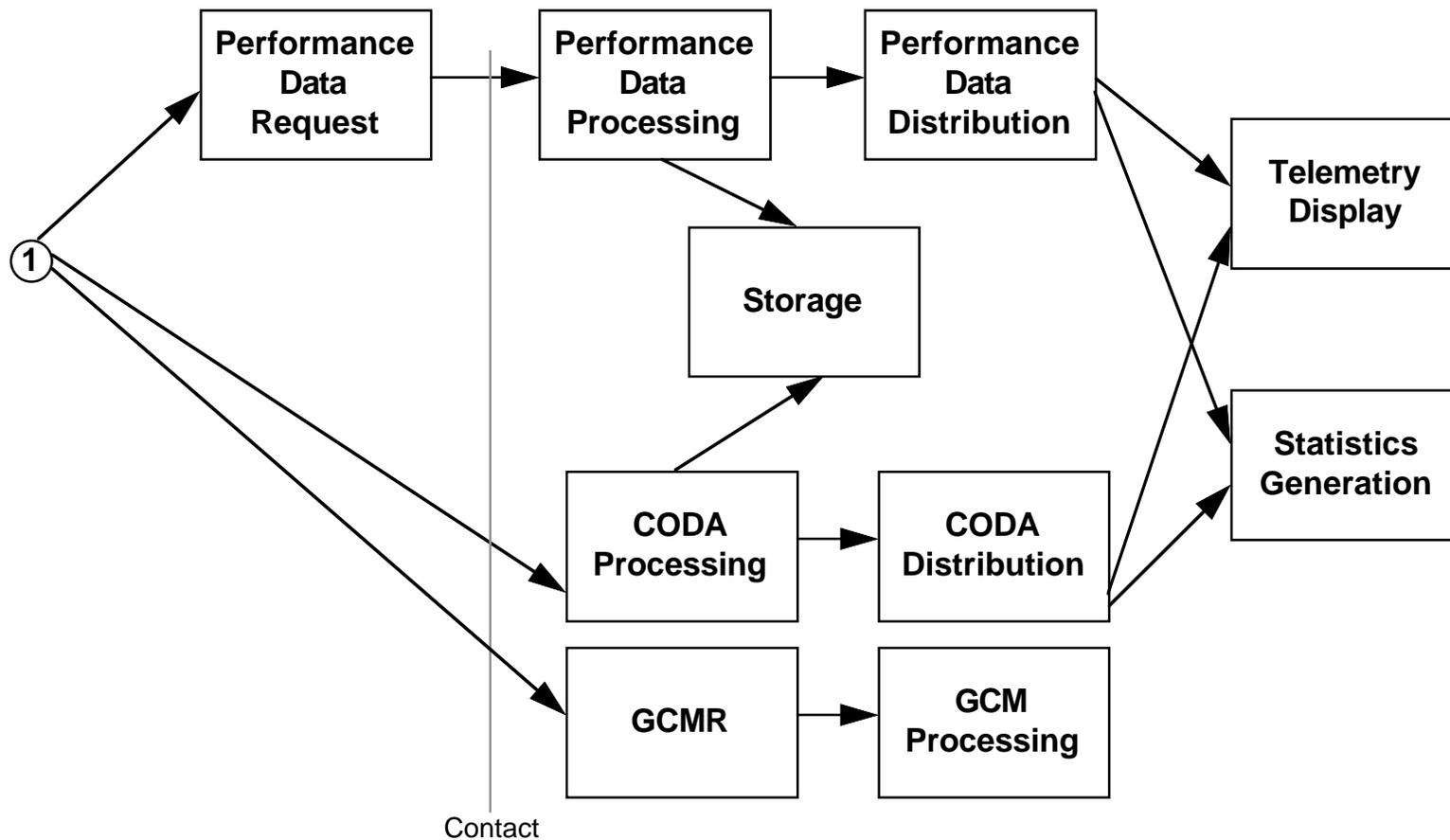
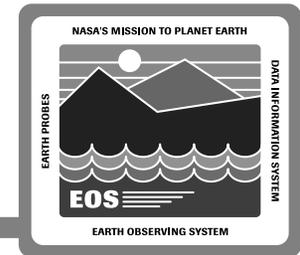
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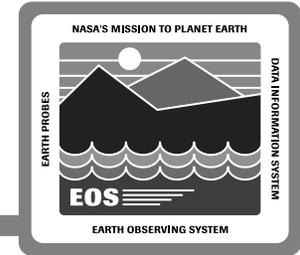
Post-Contact

- Spacecraft Telemetry Playback
- Spacecraft Telemetry Merge
- Statistics Generation

Real-Time Scenario Contact (cont.)



Real-Time Scenario Contact Overview



Performance Data Request

- Request forwarded to the NCC asking for performance data associated with a scheduled contact

Performance Data Processing

- Receipt and processing of performance data from the NCC

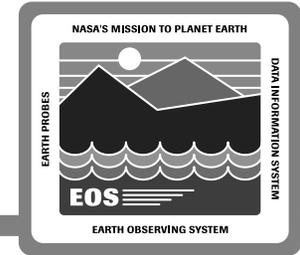
Storage

- Incoming data will be stored as it is received in the format it was received

Performance Data Distribution

- Distribution of processed performance data
 - to users for display
 - for automatic statistics generation

Real-Time Scenario Contact Overview (cont.)



Telemetry Display

- The same types of display capabilities will be provided for ground telemetry and spacecraft telemetry

Statistics Generation

- Statistics generation for Performance Data and CODAs will be performed in real-time

Ground Control Message Request (GCMR)

- Request forwarded to the NCC asking for ground control message

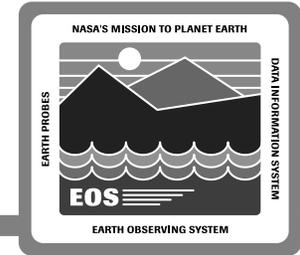
Ground Control Message Processing

- Receipt and processing of ground control message from the NCC

Key Term:

ground telemetry - status and accounting data for the ground system

Real-Time Scenario Contact Overview (cont.)



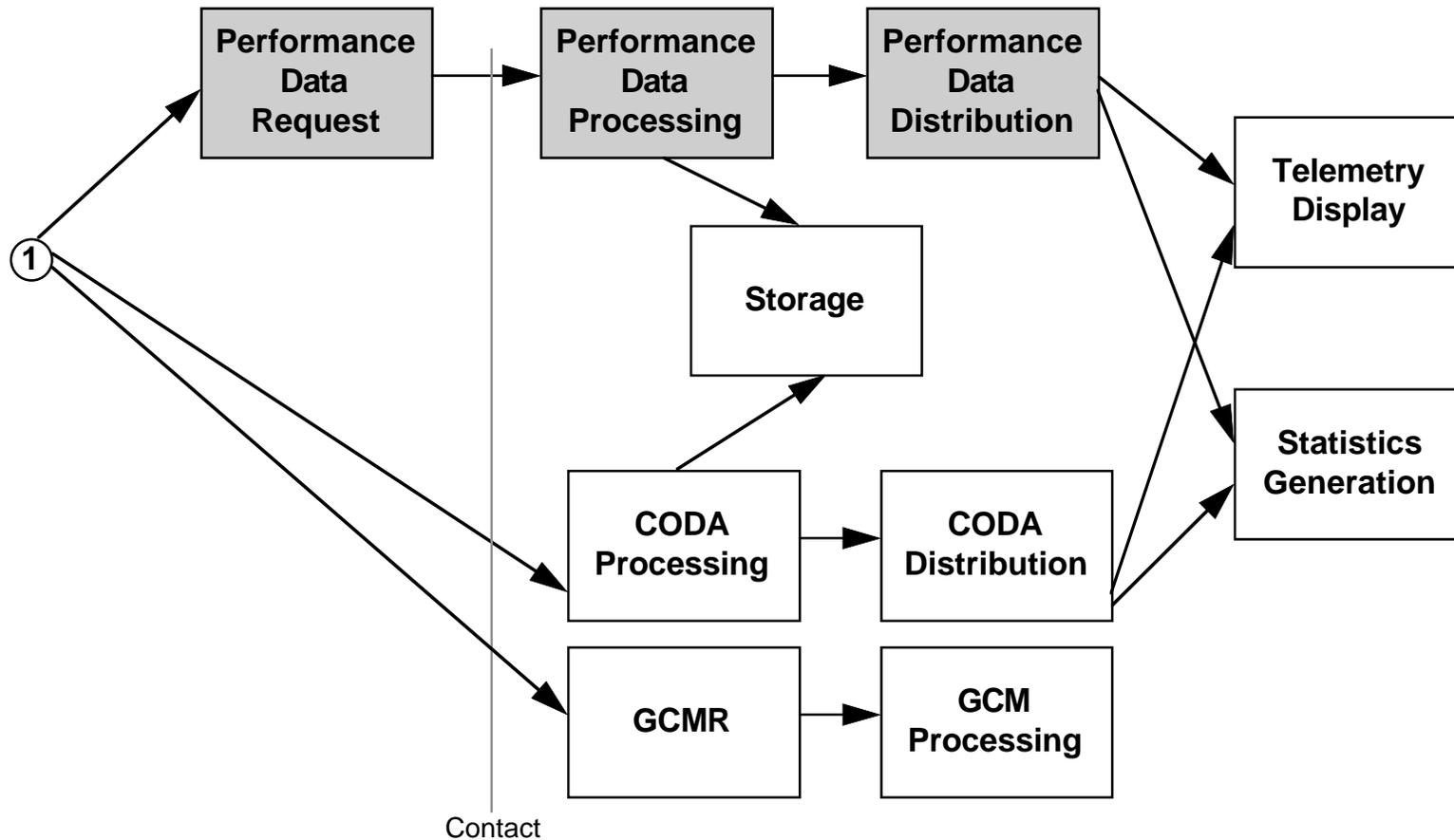
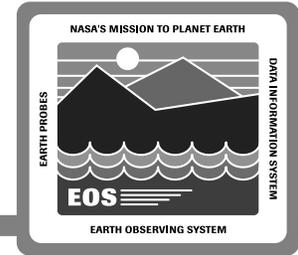
CODA Processing

- **Receipt and processing of CODA data from the EDOS**

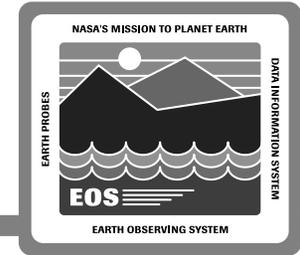
CODA Distribution

- **Distribution of processed CODA data**
 - **to users for display**
 - **for automatic statistics generation**

Performance Data Request/Processing/Distribution



Performance Data Request/ Processing/Distribution Description



User requests User Performance Data from NCC

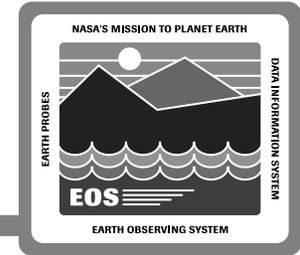
User Performance Data messages are received from NCC every 5 seconds during spacecraft contact until disabled by another user request

Other messages from NCC include:

- **Return Channel Time Delay Measurements Message (used for spacecraft clock correlation)**
- **Acquisition Failure Notification Message**
- **Time Transfer Message (used for spacecraft clock correlation)**

DSN monitor blocks processed in similar fashion

Performance Data Request/ Processing/Distribution Design



User initiates Performance Data Request to NCC (nominally in ground script)

Acknowledgment received within 5 seconds

Multiblock Performance Data message received within 5 seconds of the start of the contact

After each message is received, outstanding timer cancelled and another set

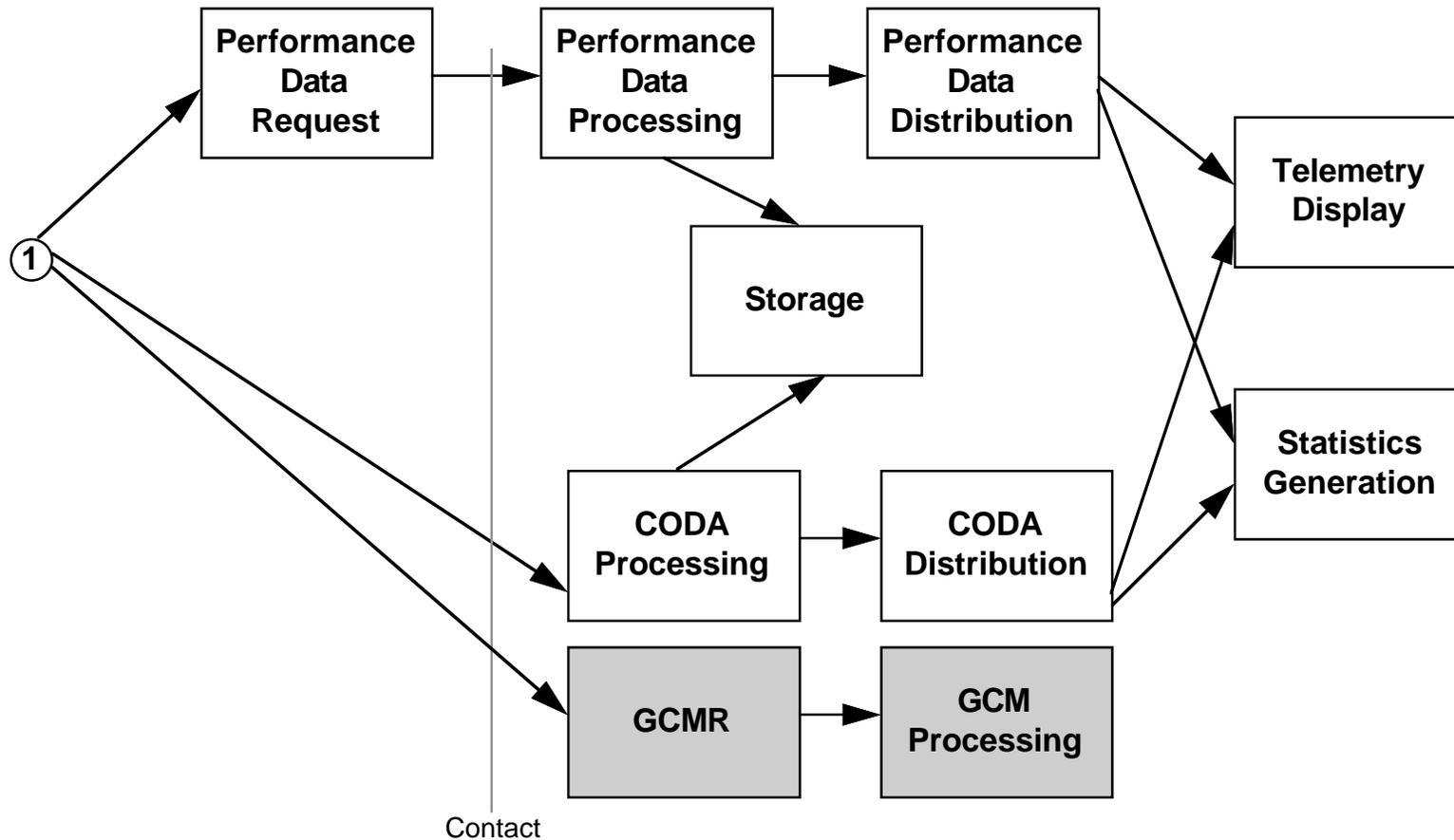
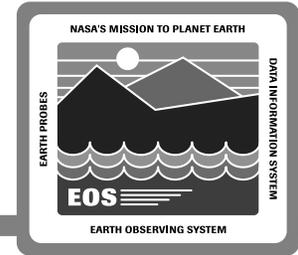
Forward each message as received to Data Management for storage

Distribute processed Performance Data for display to users

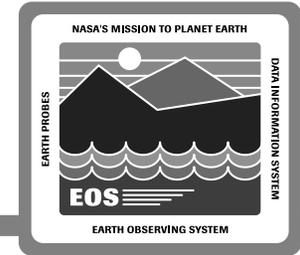
Distribute processed Performance Data to Analysis

- **for statistics generation**
- **for real-time analysis (e.g. SSR Management)**

Ground Configuration Message Request/Processing



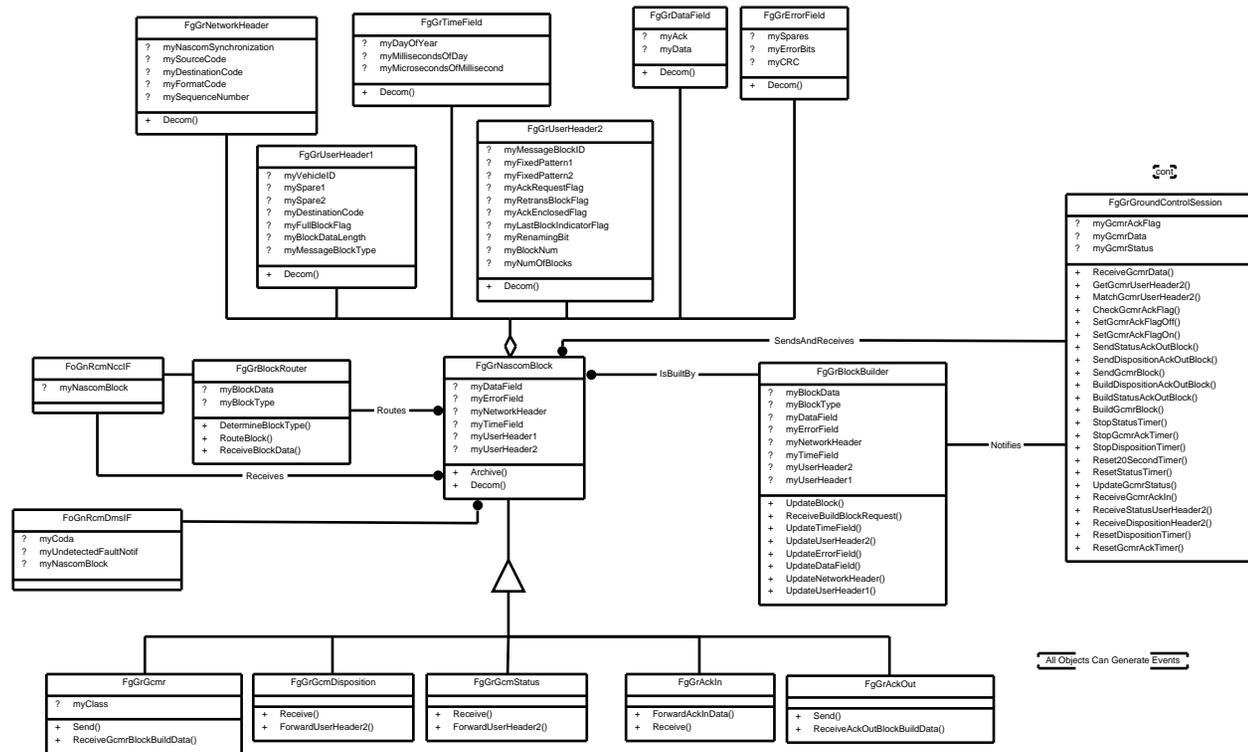
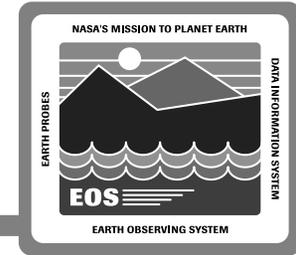
GCMR Description



Ground Control Message Request to NCC initiated by FOT user

- **Acknowledgment**
- **Disposition**
- **GCM Status**

GCMR Object Diagram

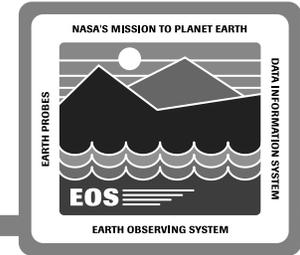


All Objects Can Generate Events

RCM/NCC Ground Control Model

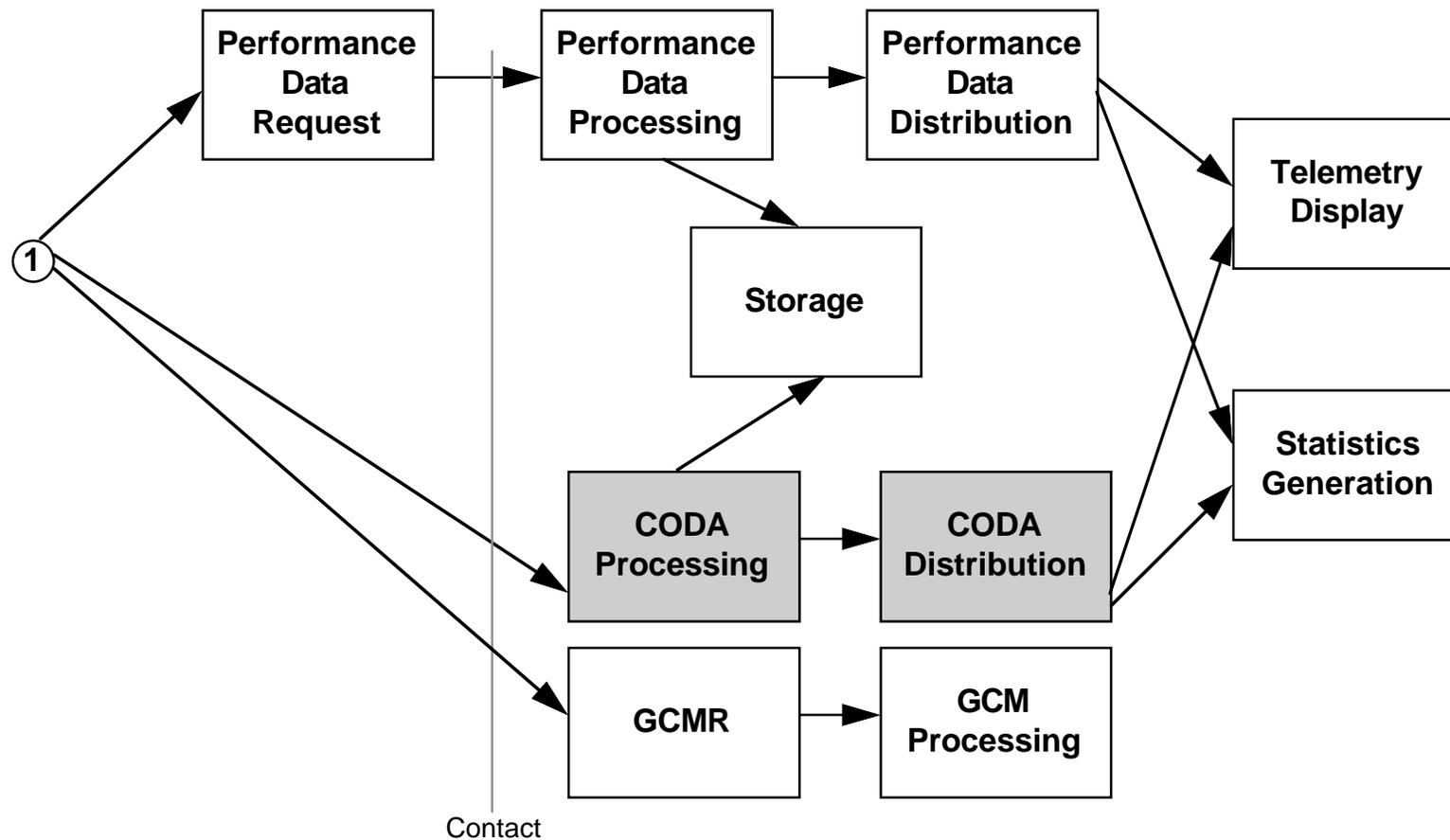
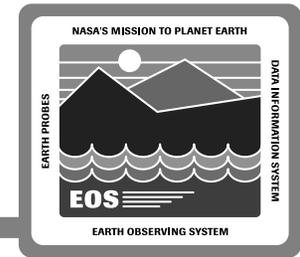
rt_45

GCMR Design

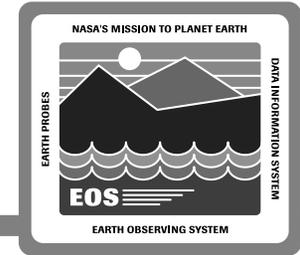


User initiates Ground Control Message Request to NCC
Acknowledgment received from NCC within 5 seconds of request
Disposition received from NCC within 20 seconds of acknowledgment
Acknowledgment of Disposition sent to NCC automatically
GCM Status received within 2 minutes of disposition
Forward each message as received to Data Management for storage
Generate event messages upon receipt of disposition and status messages

CODA Processing/Distribution



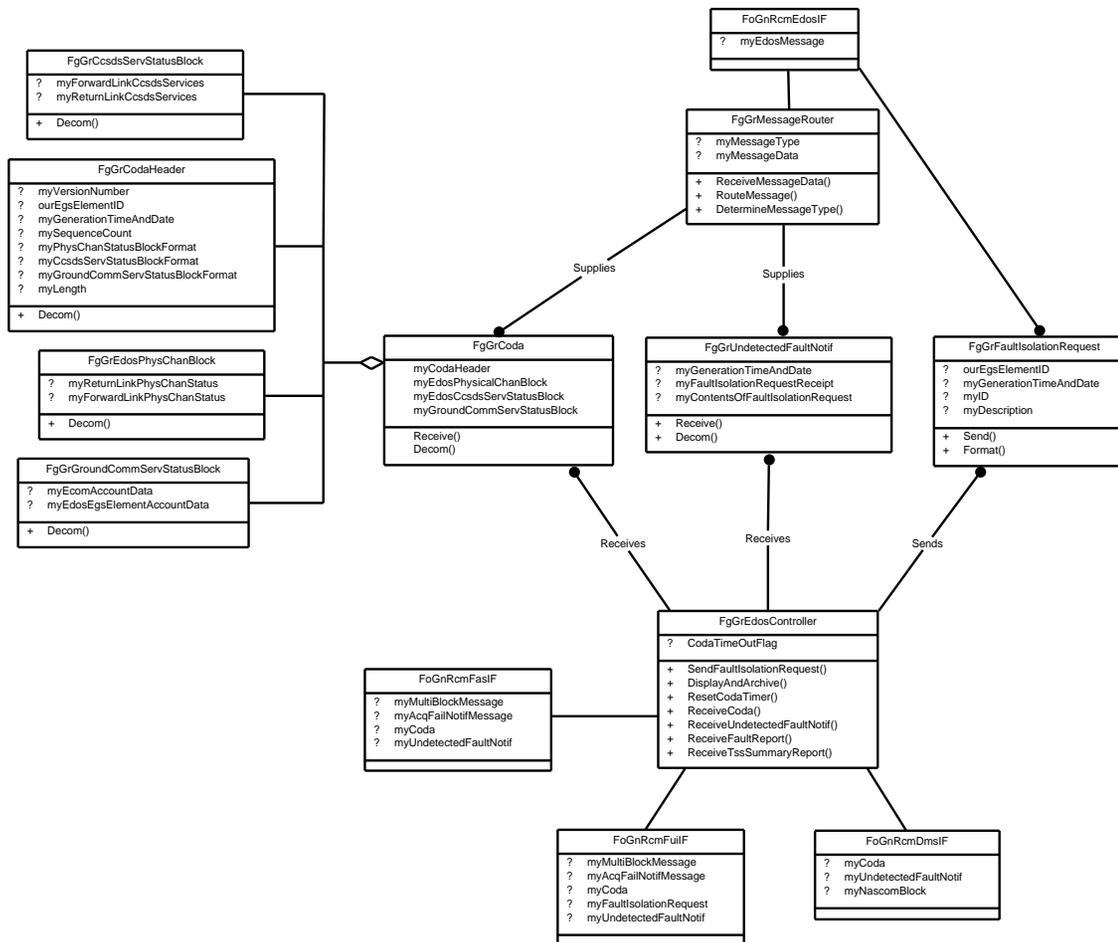
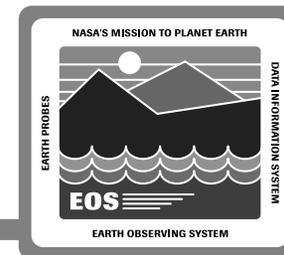
CODA Processing/Distribution Description



Customer Operations Data Accounting Reports (CODAs) contain data describing the status of services provided by EDOS and Ecom during the TDRSS Service Session (TSS)

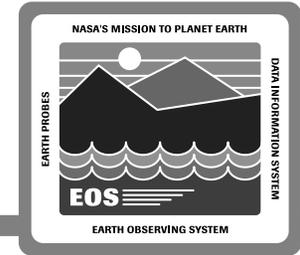
Transferred nominally every 5 seconds during a spacecraft contact (TBD)

CODA Processing/Distribution Object Diagram



RCM?EDOS Operations Management Data Model

CODA Processing/Distribution Design



Receive CODA data from the EDOS

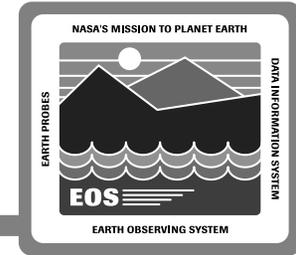
Forward CODAs as received to Data Management for storage

Distribute processed CODA data for display to users

Distribute processed CODA data to Analysis

- **for automatic statistics generation**
- **for real-time analysis (e.g. SSR Management)**

Real-Time Phase Contact (cont.)



Pre-Contact

- System Initialization
- User Connection
- Command Authority Request
- Ground Script Initialization
- NCC Communications Test
- EDOS Communications Test

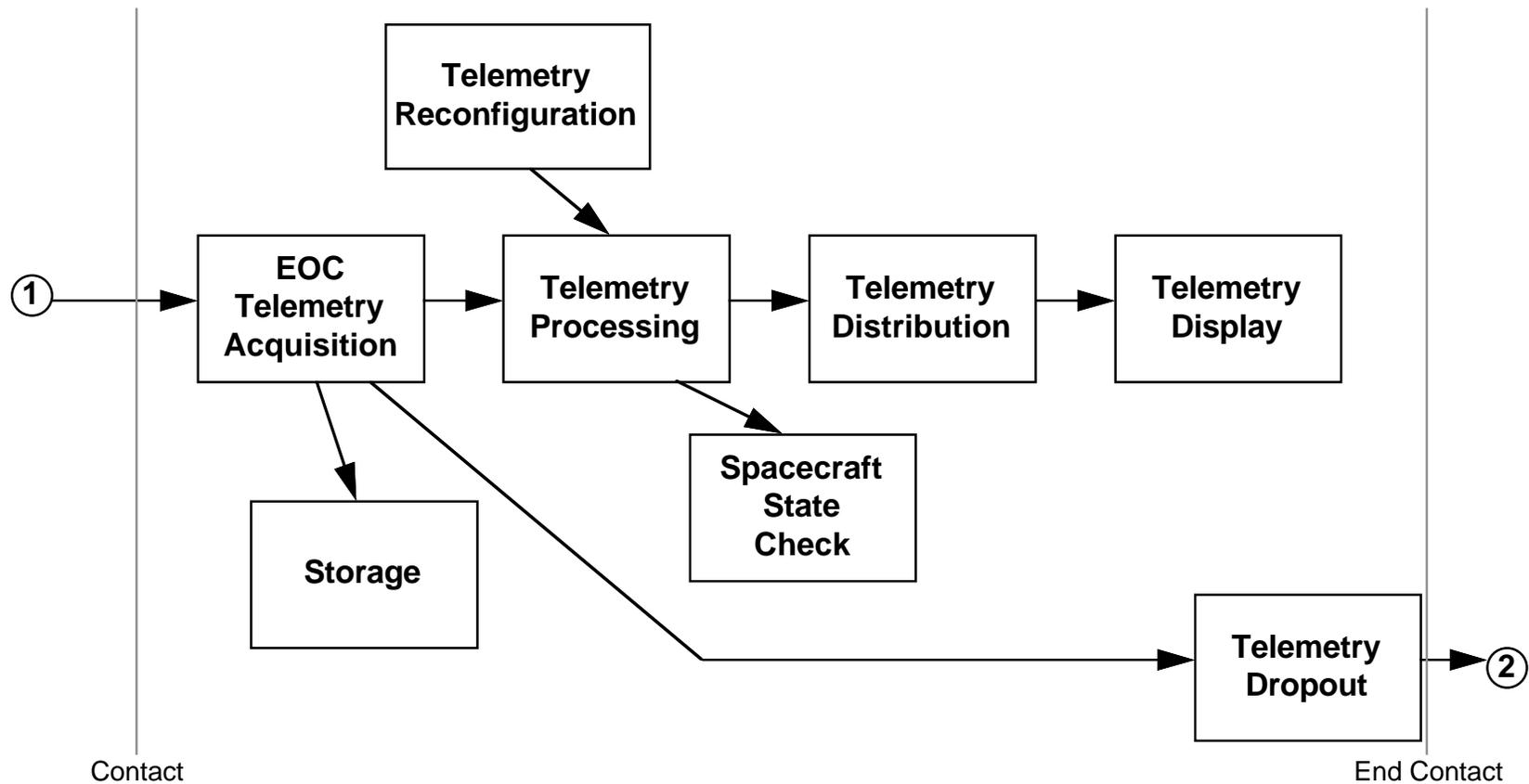
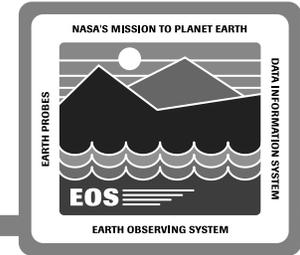
Contact

- Ground Telemetry Processing
- Spacecraft Telemetry Processing
- Spacecraft Commanding

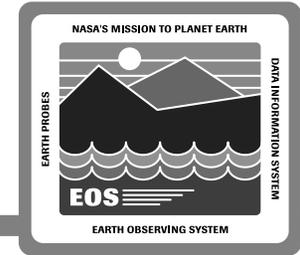
Post-Contact

- Spacecraft Telemetry Playback
- Spacecraft Telemetry Merge
- Statistics Generation

Real-Time Phase Contact (cont.)



Real-Time Phase Contact Overview (cont.)



EOC Telemetry Acquisition

- Receipt of spacecraft telemetry from EDOS (or RTS mirror)

Telemetry Processing

- Decommuration, engineering unit conversion, and limit checking

Storage

- Archive of telemetry data as it is received in the format it was received

Telemetry Distribution

- Distribution of processed telemetry data to users for display

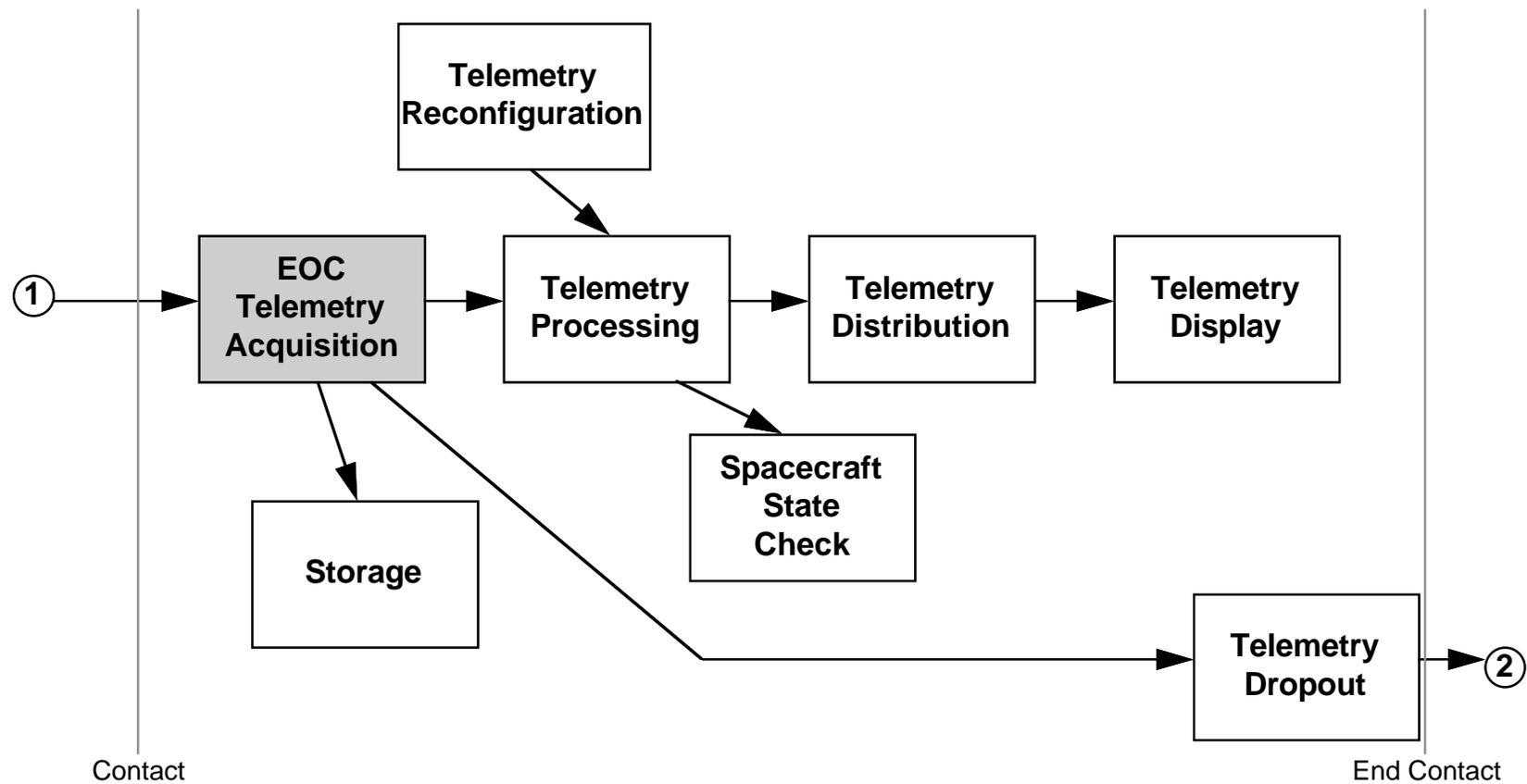
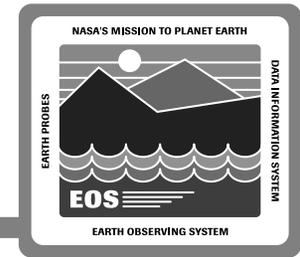
Spacecraft State Check

- Comparison of spacecraft expected state with actual state

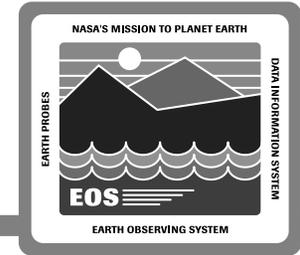
Telemetry Dropout

- Detection of the loss of spacecraft telemetry

FOS Telemetry Acquisition



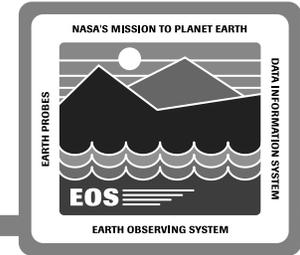
FOS Telemetry Acquisition Overview



Telemetry acquisition modes

- **Comprehensive**
 - **RTS receives telemetry from EDOS (real-time) or**
 - **RTS receives telemetry from DMS archive (simulation)**
- **Mirrored**
 - **User Station receives telemetry from RTS (real-time, simulation)**
- **Tailored**
 - **User Station receives telemetry from RTS (real-time, simulation) or**
 - **User Station receives telemetry from DMS archive (analysis)**

FOS Telemetry Acquisition Description



Receive Telemetry EDUs

- RTS prepared to accommodate EDOS connection at any time

Store Telemetry EDUs

- DMS archives telemetry for future replay and analysis

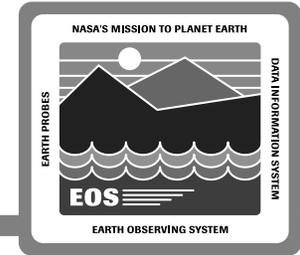
Process EDUs

- Extract header information
- Extract spacecraft CCSDS telemetry packet

Key Term:

EDU - EDOS Data Unit, message packet generated by EDOS which contains the reconstructed spacecraft telemetry packet

FOS Telemetry Acquisition Description (cont.)



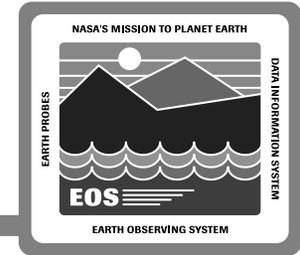
Process CCSDS telemetry packets

- Extract header information
- Extract spacecraft telemetry
 - Housekeeping
 - Health and safety
 - Standby (AM-1 Command-Telemetry Interface Unit, CTIU)
 - Diagnostic (memory dump)
stored and made available to CMS for comparison

Key Term:

CCSDS - Consultative Committee for Space Data Systems, recommendations for spacecraft telemetry and telecommand packet format and protocol.

FOS Telemetry Acquisition Scenario



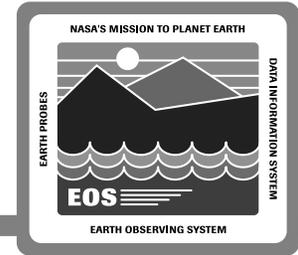
Accept EDOS initiated connection (FoGnTImEdosIF)

Receive EDOS Data Unit telemetry (FtTIEdu)

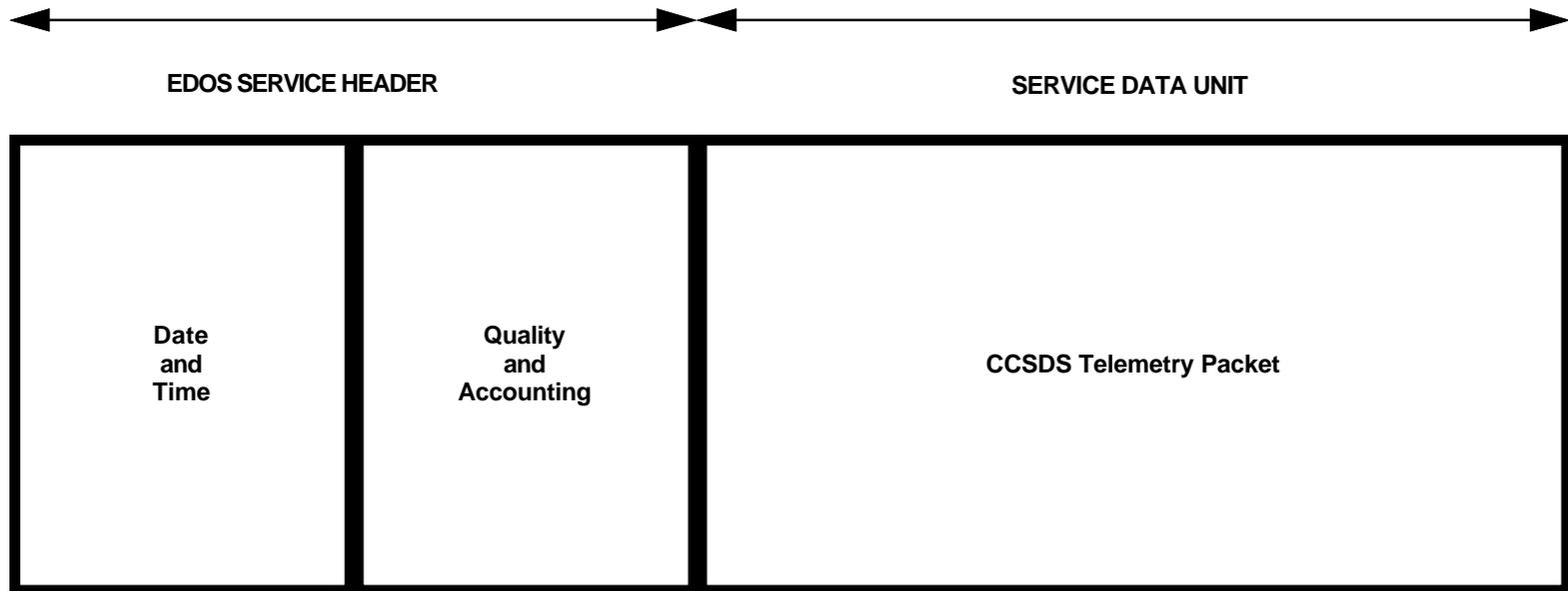
Process EDU

- **Extract EDU Service Header fields (FtTIEsh)**
 - **Service Data Unit quality / accounting**
 - **EDOS ground receipt time (FtTITimeCode)**
- **Extract EDU Service Data Unit field**
 - **Reconstructed spacecraft CCSDS telemetry packet (FtTICcsdsPacket)**

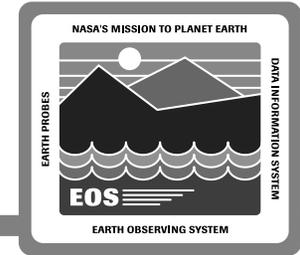
FOS Telemetry Acquisition Scenario (cont.)



EDOS Data Unit Format



FOS Telemetry Acquisition Scenario (cont.)



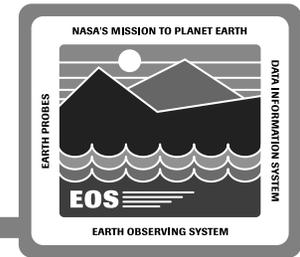
Process CCSDS packet (FtTICcsdsPacket)

- Extract packet Primary Header fields (FtTICcsdsPrimaryHeader)
 - Application Identifier (APID)
 - Length (octets)
 - Sequence count
 - Flags

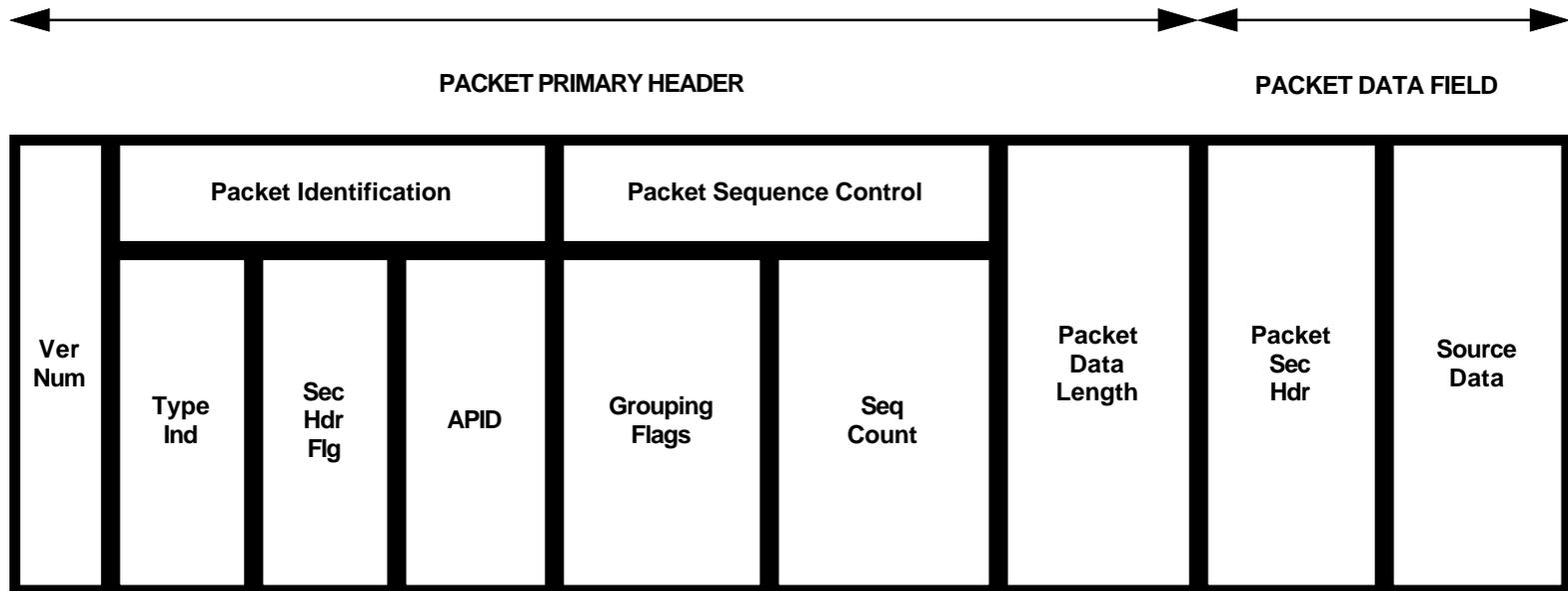
Key Term:

APID - Application Identifier, number assigned by spacecraft mission management which represents the on-board application which generated the telemetry data.

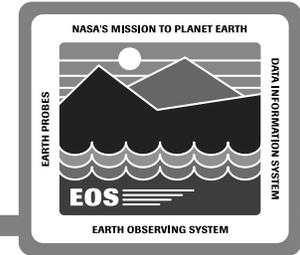
FOS Telemetry Acquisition Scenario (cont.)



CCSDS Packet Telemetry Source Packet Format



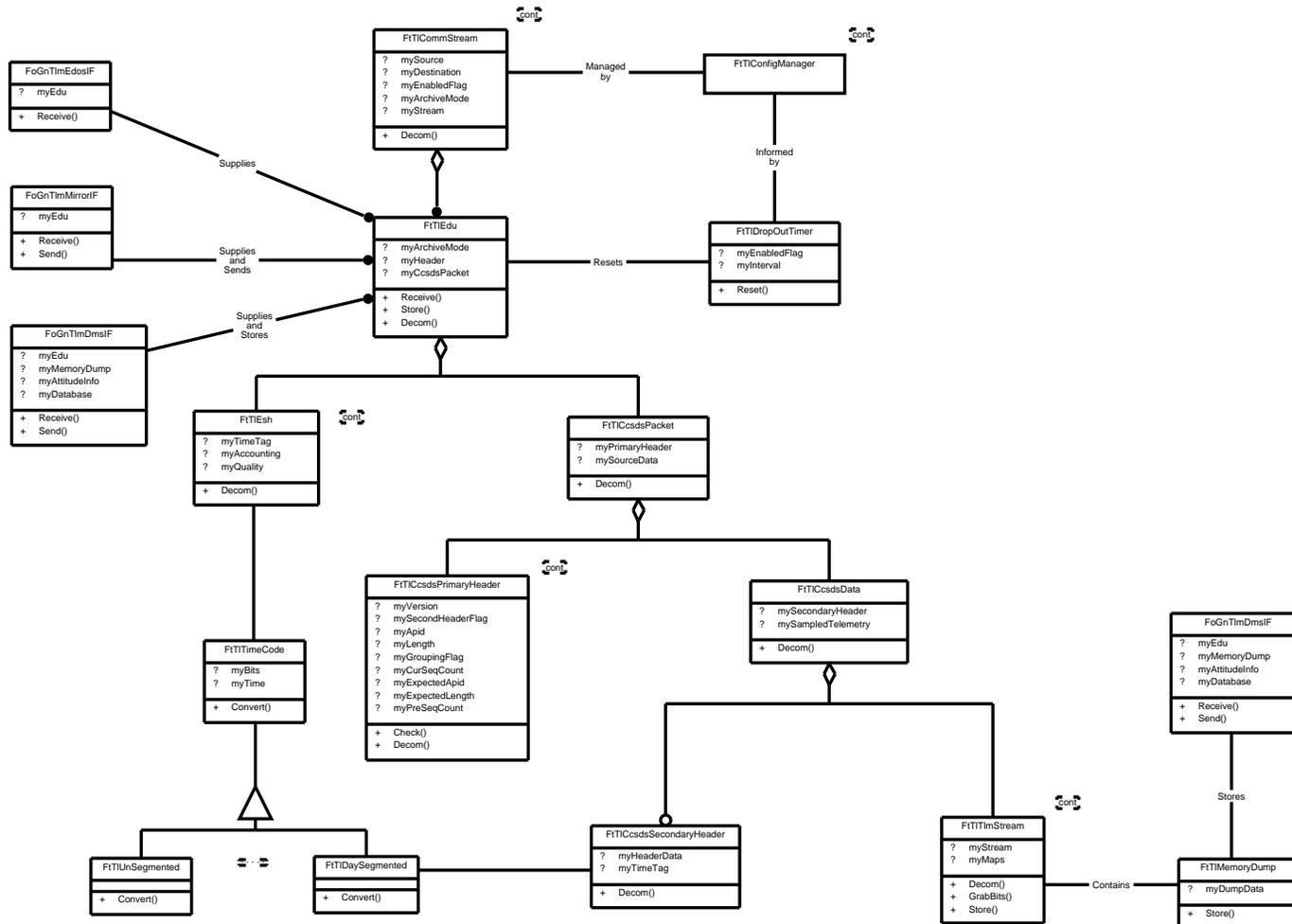
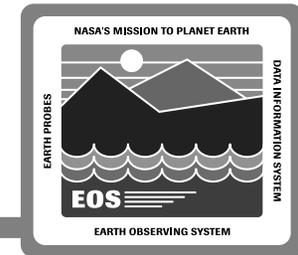
FOS Telemetry Acquisition Scenario (cont.)



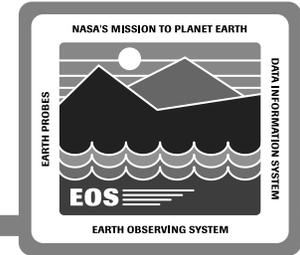
Process CCSDS packet (cont.)

- **Extract packet Data Fields (FtTICcsdsData)**
 - **Secondary Header (FtTICcsdsSecondaryHeader)**
packet spacecraft time tag (FtTIDaySegmented)
 - **Source Data (FtTITImStream)**

FOS Telemetry Acquisition Object Diagram



FOS Telemetry Acquisition Design Benefits



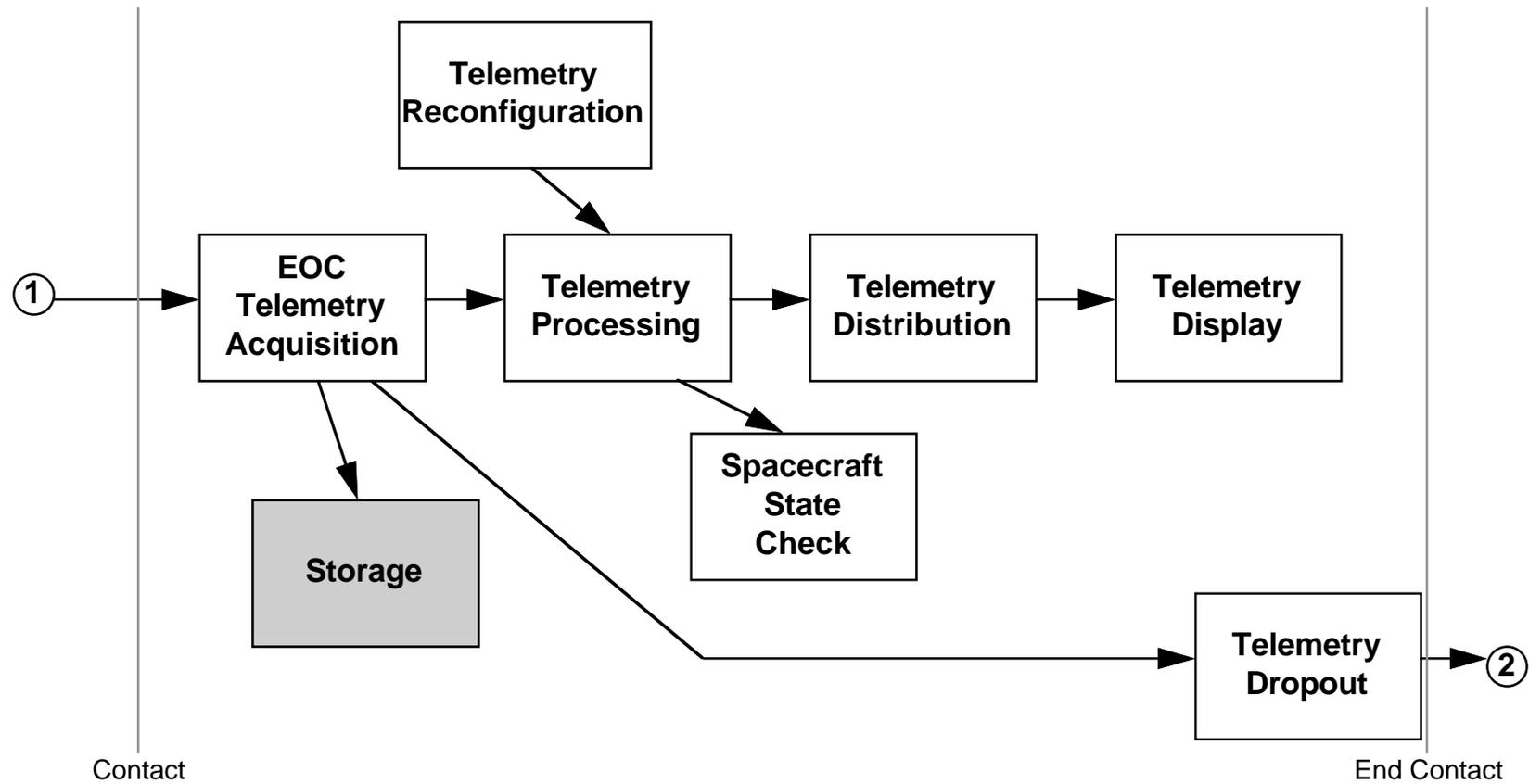
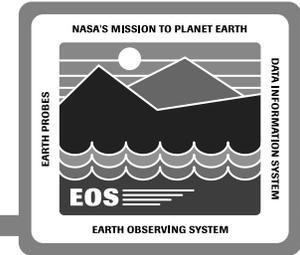
Real-time telemetry format changes not necessary

- RTS ready to process any given spacecraft stream

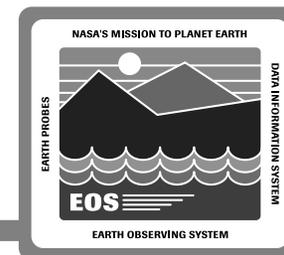
Consistent telemetry interface

- Always receive and process EDUs
 - Real-time
 - Replay
 - Analysis

Telemetry Storage



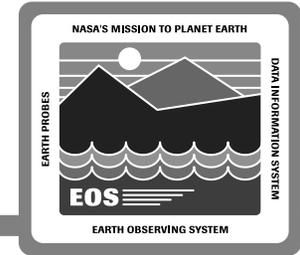
Telemetry Storage Description



Store spacecraft and ground telemetry information

- **Spacecraft telemetry**
 - Housekeeping EDUs
 - Health & Safety EDUs
 - Standby CTIU EDUs
 - Diagnostic EDUs
- **Ground telemetry**
 - **NCC**
 - Performance Messages**
 - TTMs**
 - RCTDs**
 - **EDOS**
 - CODAs**

Telemetry Storage Scenario



Accept telemetry data unit (FoDsTImRecord)

Attach header information for future data retrieval (FdDsDmsTImRecord)

- Time
- Data type
- Spacecraft Identifier

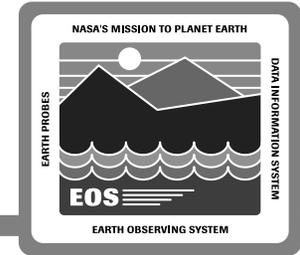
Store header and telemetry information (FdArTImArchive)

Update archive database metadata (FdDbMetadata)

- File information

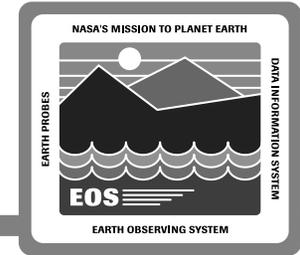


Telemetry Storage Object Diagram



Available in hardcopy only.

Telemetry Storage Design Benefits



Consistent Data Management interface and storage mechanism

- Header
- Telemetry

Global accessibility

- Information available to any FOS user
- Information available immediately following storage

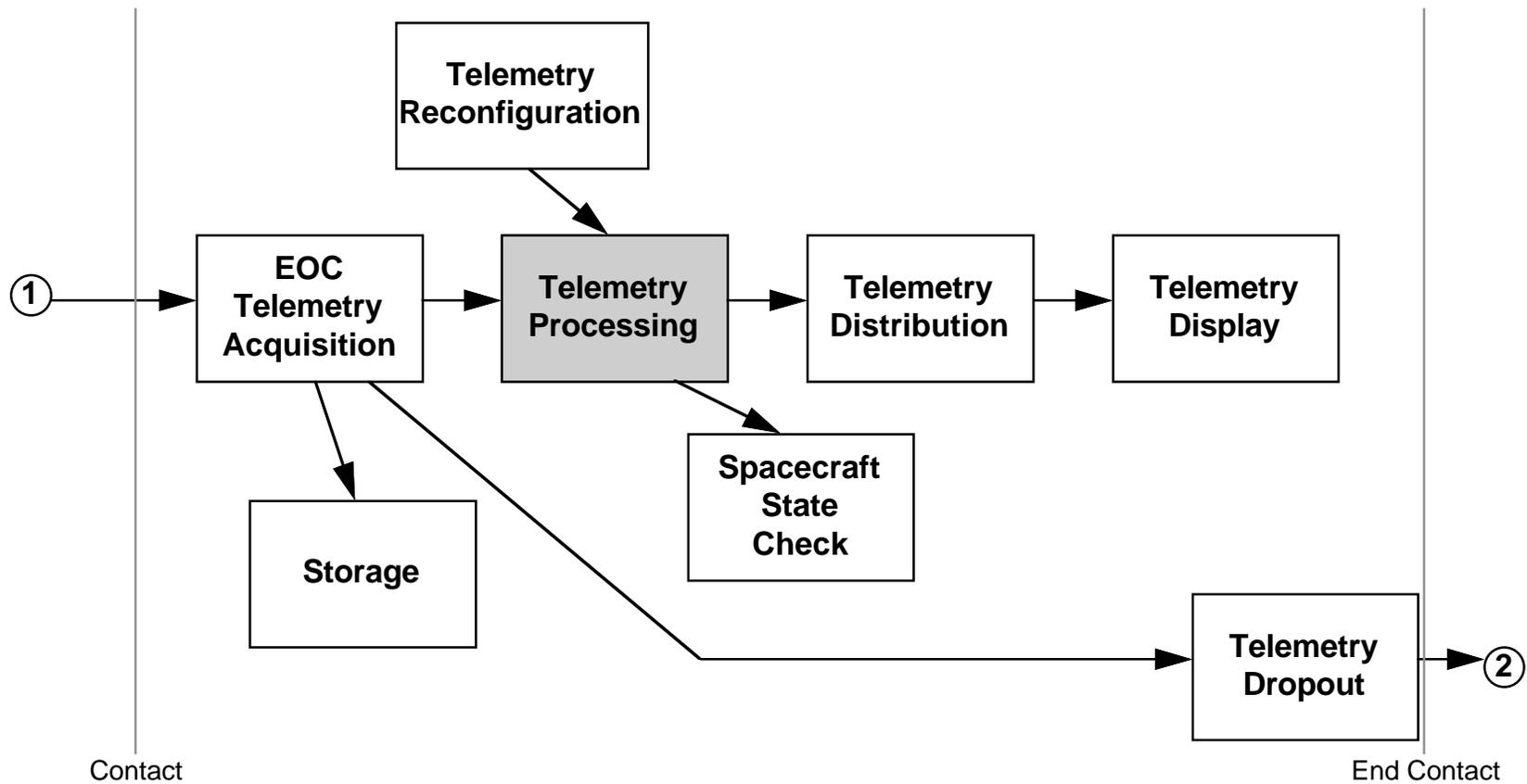
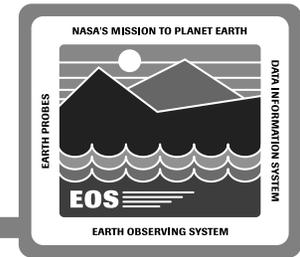
Storage method provides quick data retrieval

- Header information attached
- Data base updated

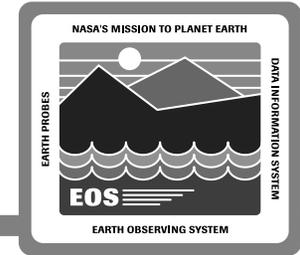
Storage method eases anomaly resolution, replay, analysis, and simulation

- Entire telemetry unit stored (e.g. EDU, Nascom Block)

Telemetry Processing



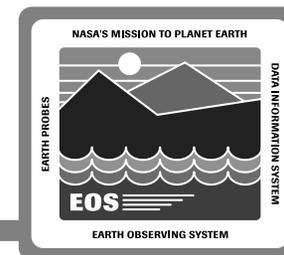
Telemetry Processing Overview



Telemetry processing modes

- **Comprehensive**
 - **RTS processes all telemetry parameters**
- **Mirrored**
 - **User Station telemetry processing synchronized with RTS**
- **Tailored**
 - **User Station telemetry processing may be customized**

Telemetry Processing Description



Decommutate packet telemetry

- Decommutation algorithm based upon APID
- Decommutation algorithm based upon sequence number (AM-1)

Extract telemetry parameter bit fields

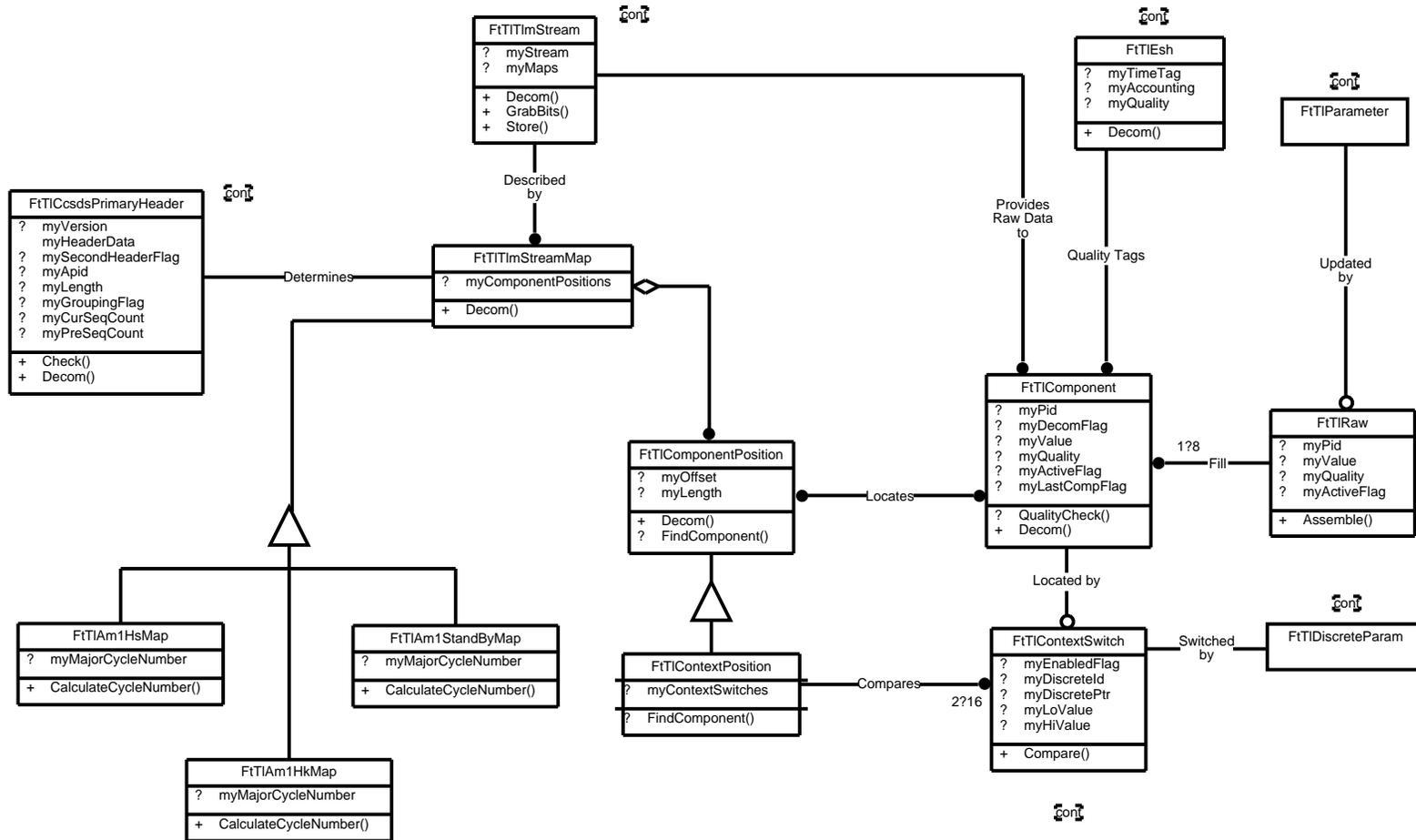
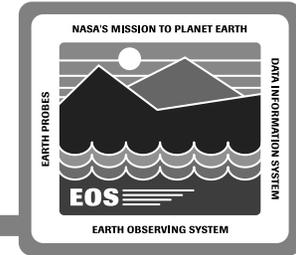
- Extraction map supports:
 - Multiple component / position parameters
 - Context dependent parameters
- Selective decommutation supports:
 - Selection by parameter or spacecraft subsystem group

Tag decommuted parameter with ESH quality

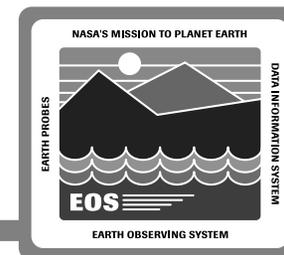
Key Term:

ESH - EDU Service Header, contains EDU time tag, quality, and accounting information

Telemetry Processing Object Diagram (1 of 4)



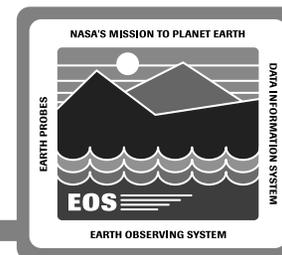
Telemetry Processing Scenario (1 of 4)



Decommutate packet telemetry data (FtTITImStream)

- **Determine proper decommutation map (FtTITImStreamMap)**
 - Using APID and optionally sequence number (FtTICcsdsPrimaryHeader)
- **Extract parameter bit fields (FtTIComponent)**
 - Using position information within map (FtTIComponentPosition)
 - Using context dependence (FtTIContextPosition) and context switch (FtTIContextSwitch)
- **Quality tag the parameter bit fields with ESH quality (FtTIEsh)**
- **Assemble parameter values (FtTIRaw)**
 - From single component
 - From multiple components
- **Update raw parameter telemetry values (FtTIParameter)**

Telemetry Processing Description (cont.)



Calculate derived telemetry

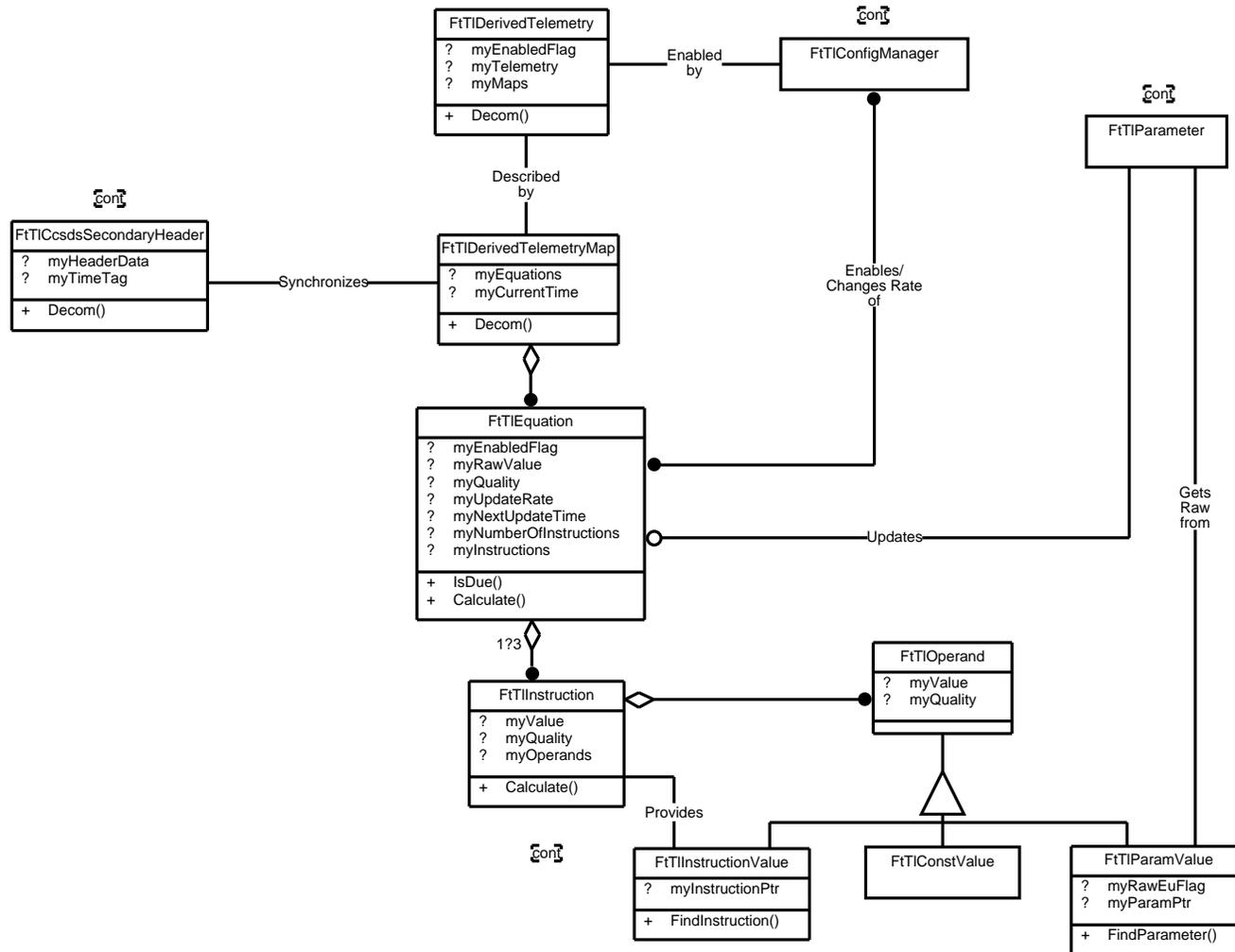
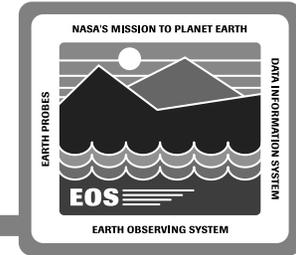
- Construction algorithm data base defined
- Construction algorithm synchronized with packets

Construct derived parameter

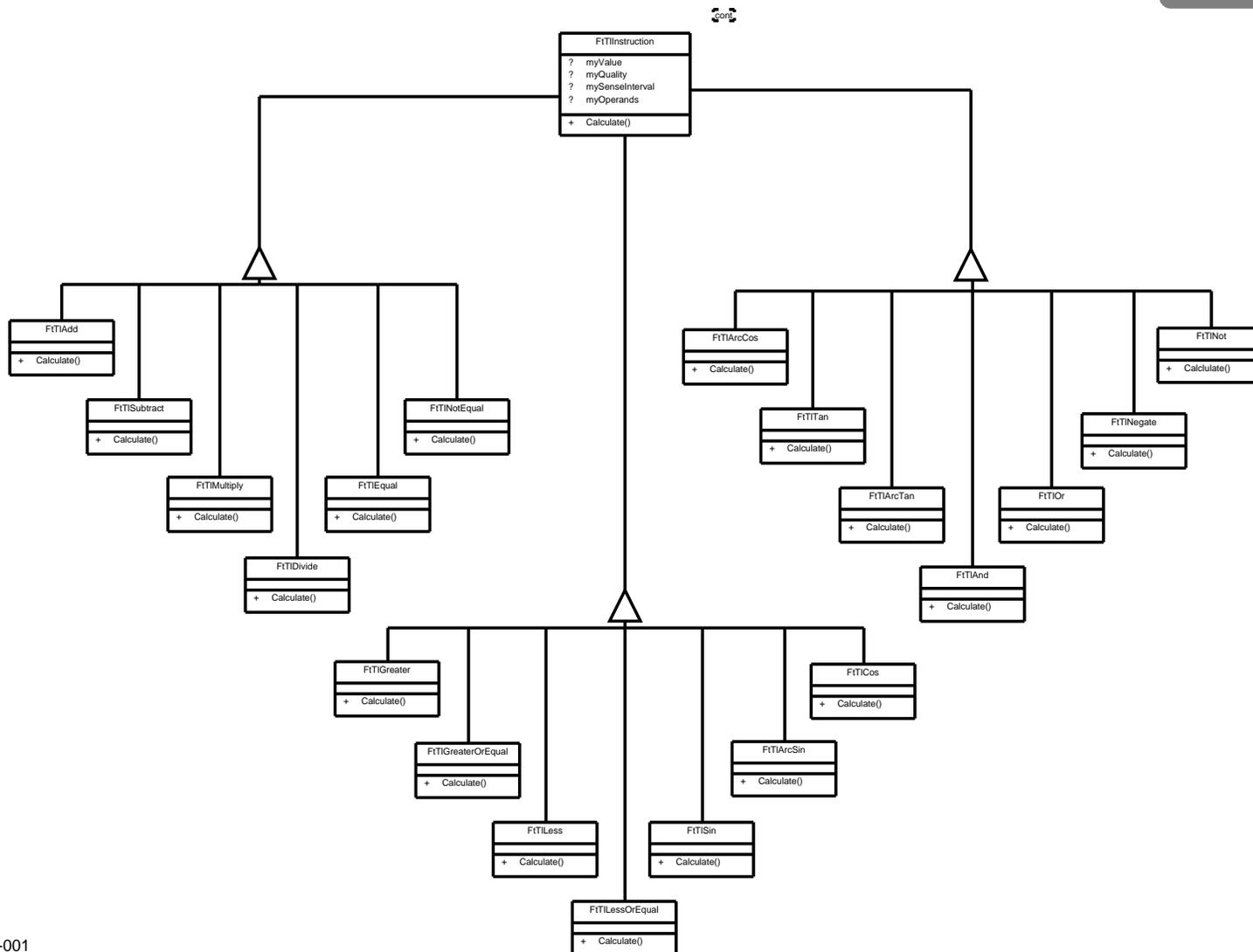
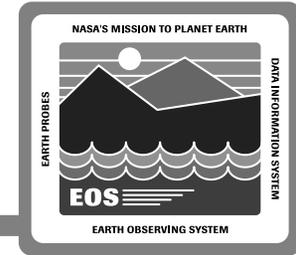
- Construction map supports:
 - Multiple instruction equations (up to three)
 - Two operands per instruction, each operand may be a:
 - previous instruction value
 - current parameter value
 - constant value
- Instruction operator is arithmetic or logical

Tag derived parameter with operand quality

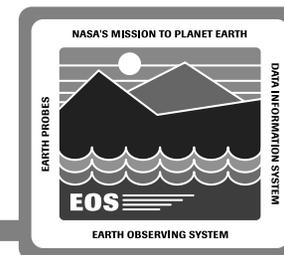
Telemetry Processing Object Diagram (2 of 4)



Telemetry Processing Object Diagram (3 of 4)



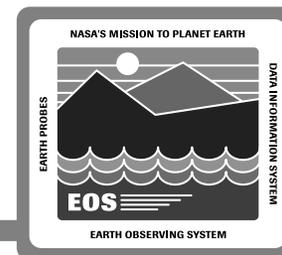
Telemetry Processing Scenario (2 of 4)



Generate derived telemetry data (FtTIDerivedTelemetry)

- Determine parameters to be calculated
 - Using derived telemetry engine (FtTIDerivedTelemetryMap)
- Compare packet time stamp with next update time for the derived parameters (FtTIEquation)
- Calculate the equations if due
 - Using set of instructions (FtTIInstruction)
- Update raw parameter telemetry values (FtTIParameter)

Telemetry Processing Description (cont.)



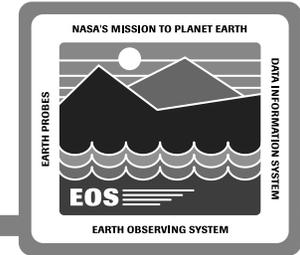
Determine engineering unit (EU) value

- Analog parameter EU conversion supports:
 - Polynomial algorithm ($y = C_0 + C_1x + C_2x^2 + \dots C_7x^7$)
 - Line segment algorithm ($y = mx + b$)
 - Exponential algorithm ($y = C_0 + C_1e^{(c2x)}$)
- Multiple EU conversions (up to four per parameter)
 - Context dependent selection

Key Term:

EU - Engineering Unit, unit of measure assign to a given parameter (e.g. volts, amperes, degrees)

Telemetry Processing Description (cont.)



Determine parameter limit status

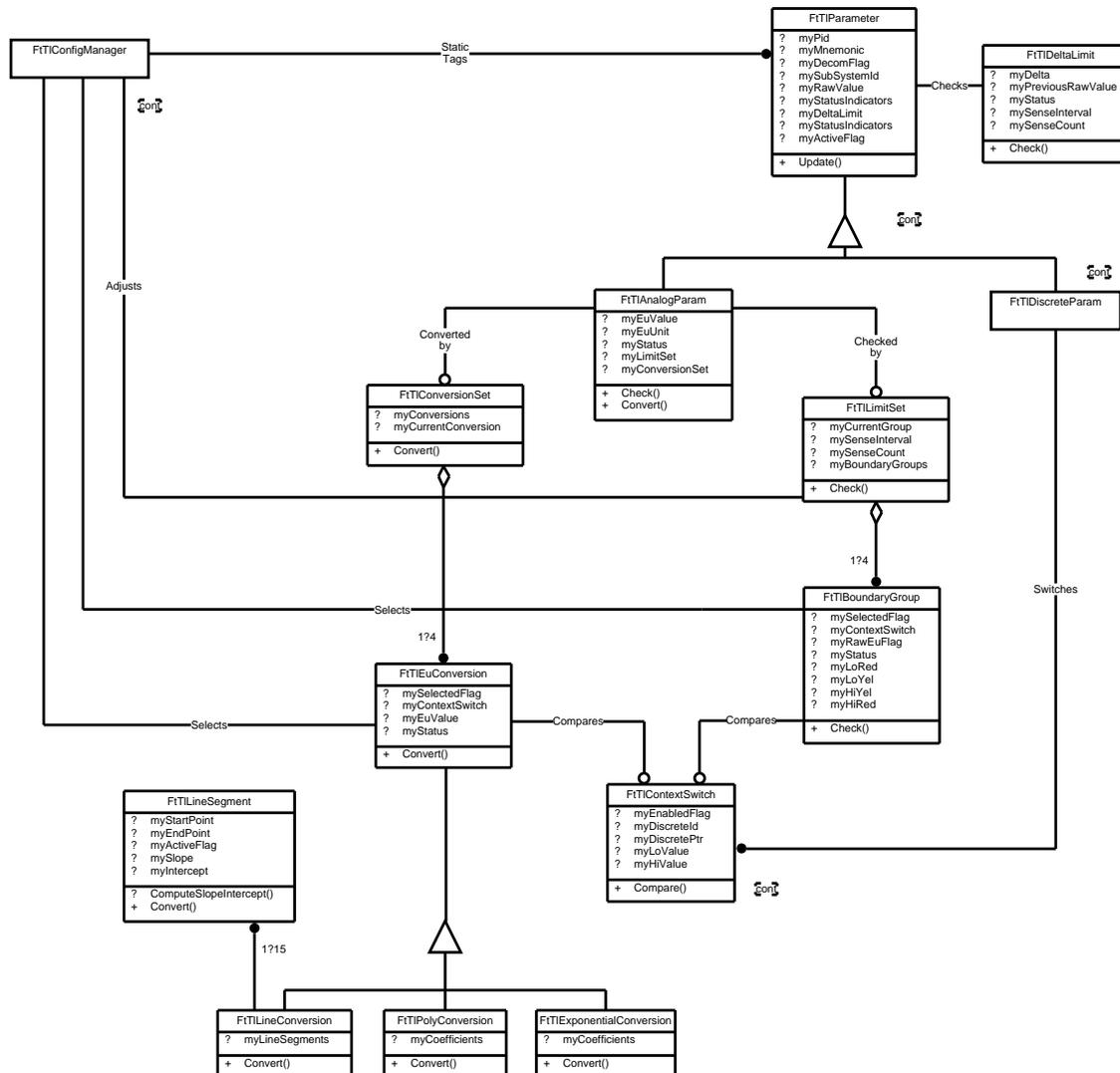
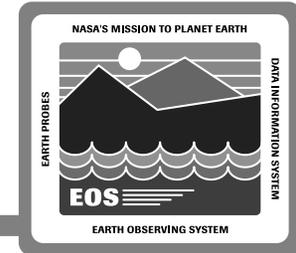
- **Delta limit** supports discrete as well as analog parameters
 - Checks Raw value
- **Boundary limit** supports analog parameters
 - Checks Raw or EU value
- **Multiple boundary limit groups (up to four per parameter)**
 - Context dependent selection
 - Each group contains LoRed, LoYellow, HiYellow, and HiRed limits

Key Terms:

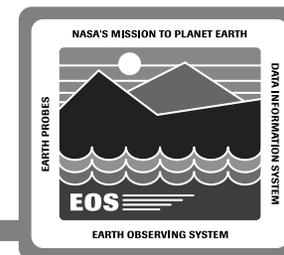
Delta limit - maximum allowable value change in successive samples of a given parameter.

Boundary limit - range value associated with a warning or alarm.

Telemetry Processing Object Diagram (4 of 4)

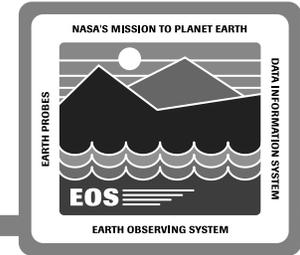


Telemetry Processing Scenario (3 of 4)



- EU convert an analog parameter raw value(FtTIAAnalogParam)**
- **Select proper conversion algorithm (FtTIConversion)**
 - From predefined set of conversions (FtTIConversionSet)
determine if user selected
determine if context dependent (FtTIContextSwitch)
 - **Perform EU conversion using conversion type:**
 - Polynomial (FtTIPolyConversion)
 - Line segment (FtTILineConversion)
 - Exponential (FtTIExponentialConversion)
 - **Update parameter with EU value**

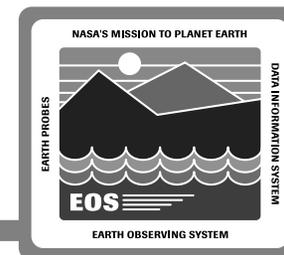
Telemetry Processing Design (4 of 4)



Limit check an analog parameter (FtTIAAnalogParameter)

- **Select proper limit group (FtTIBoundaryGroup)**
 - **From predefined set of groups (FtTILimitSet)**
 - determine if user selected**
 - determine if context dependent (FtTIContextSwitch)**
- **Perform limit checks using boundary group range values**
- **Update parameter with limit status**

Telemetry Processing Design Benefits



Permits selective telemetry decommutation

- Real-time data base changes not required
 - Entire telemetry decom map always loaded during initialization
- Processing load decreased
 - Permits multiple simultaneous real-time and off-line telemetry analysis operations

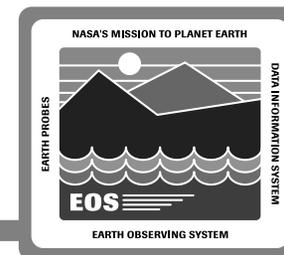
Updates derived telemetry based upon spacecraft clock

- Consistent mechanism for real-time and replay / analysis

Extensible

- Accommodates future telemetry types
- Accommodates parameter component extraction from multiple packets
 - Parameter assembled when final component processed
 - Parameter quality based upon tag of each component

Telemetry Processing Design Benefits (cont.)



Telemetry processing prototype

- Simulates AM-1 H&S and H/K CCSDS packets
- Decommutes and processes packets
 - Benchmark results on HP 715 / 50 workstation:
Housekeeping (622 Kbps / 47 pps)
1600 spacecraft telemetry parameters per packet

Health and Safety (480 Kbps / 290 pps)

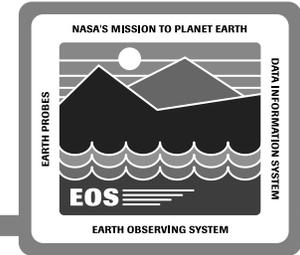
125 spacecraft telemetry parameters per packet

Health and Safety (400 Kbps / 244 pps)

125 spacecraft telemetry parameters per packet

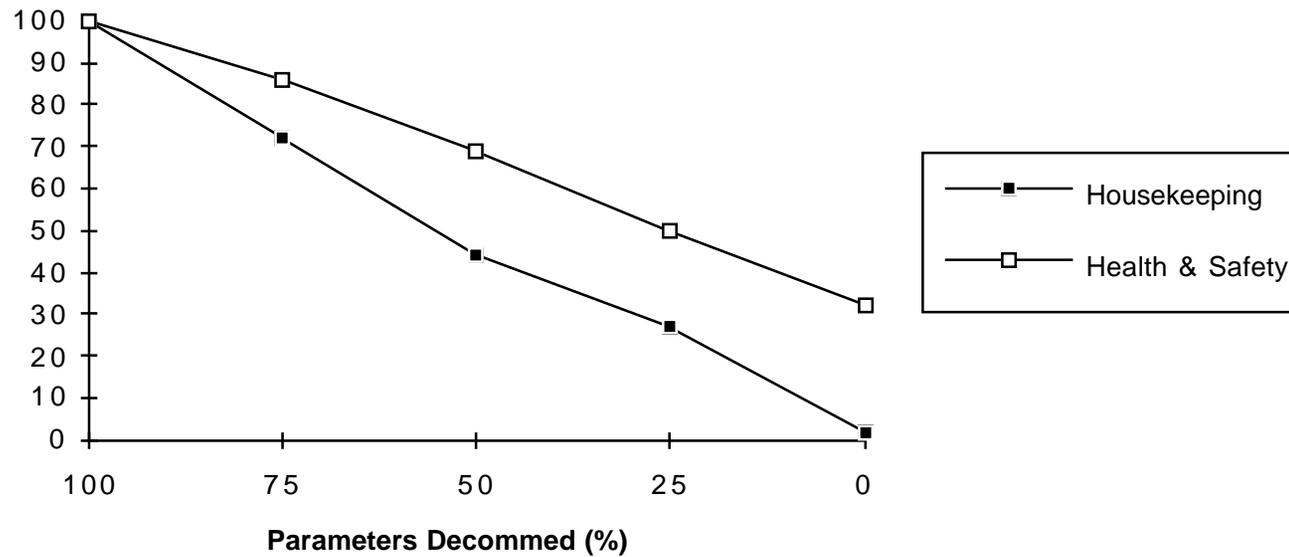
10 derived telemetry parameters per packet

Telemetry Processing Design Benefits (cont.)

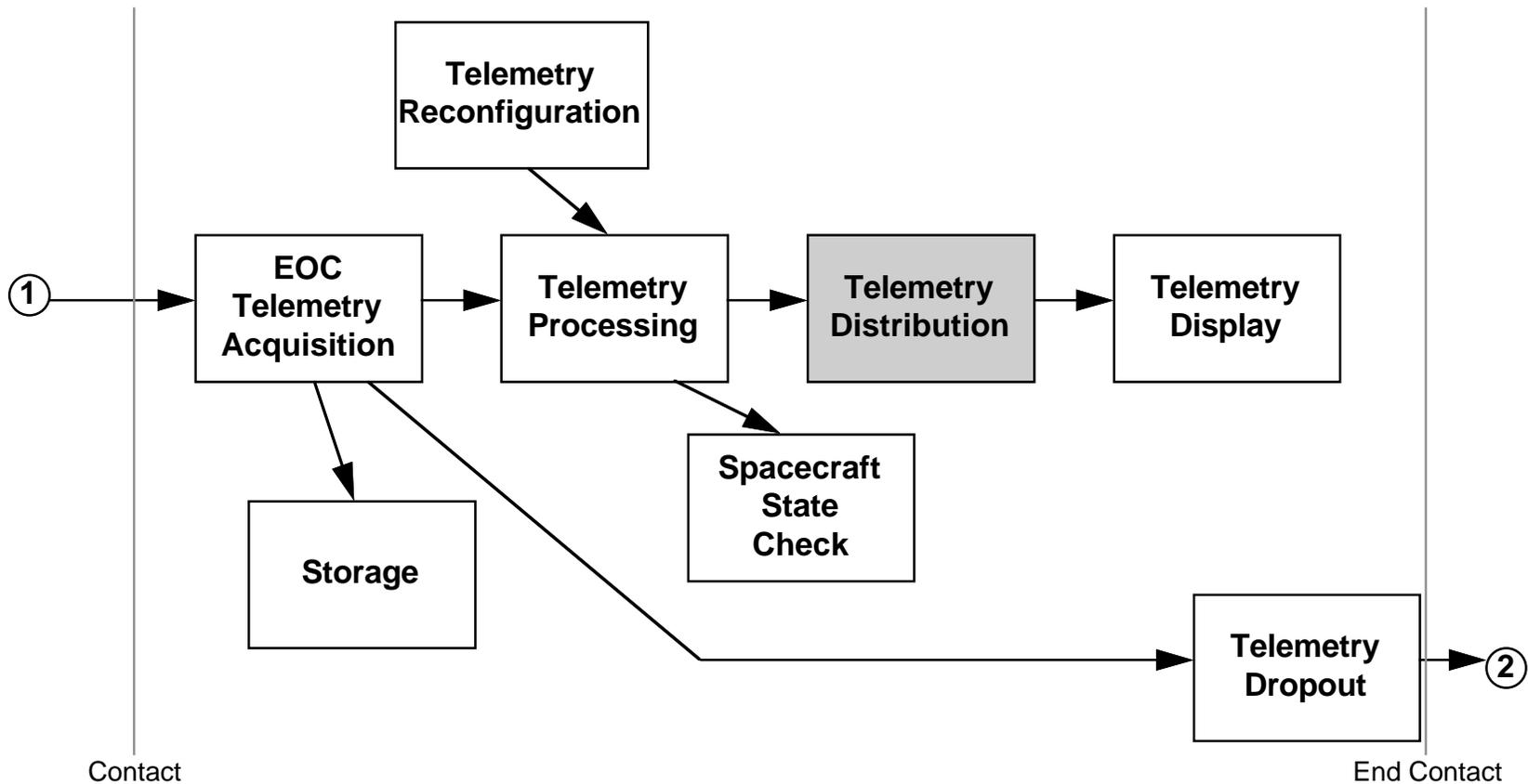
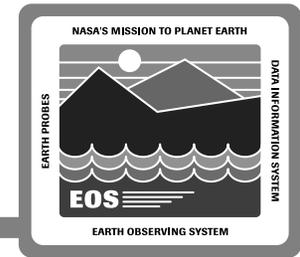


Telemetry processing prototype

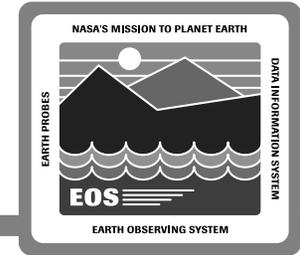
Selective Decom Comparison



Telemetry Distribution



Telemetry Distribution Description



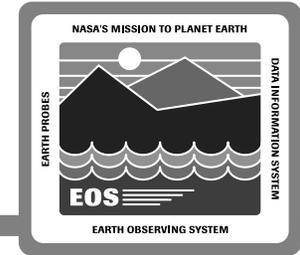
Utilizes client application parameter list

- **Client subset list determines telemetry collection**
 - Identifies parameters client application wishes to receive
 - One list received from each client application
 - Typical real-time clients include:
 - display
 - analysis (e.g. SSR monitor)
 - Flight Dynamics Facility (attitude telemetry parameters)

Key Term:

SSR - Solid State Recorder, spacecraft data recorder.

Telemetry Distribution Description (cont.)



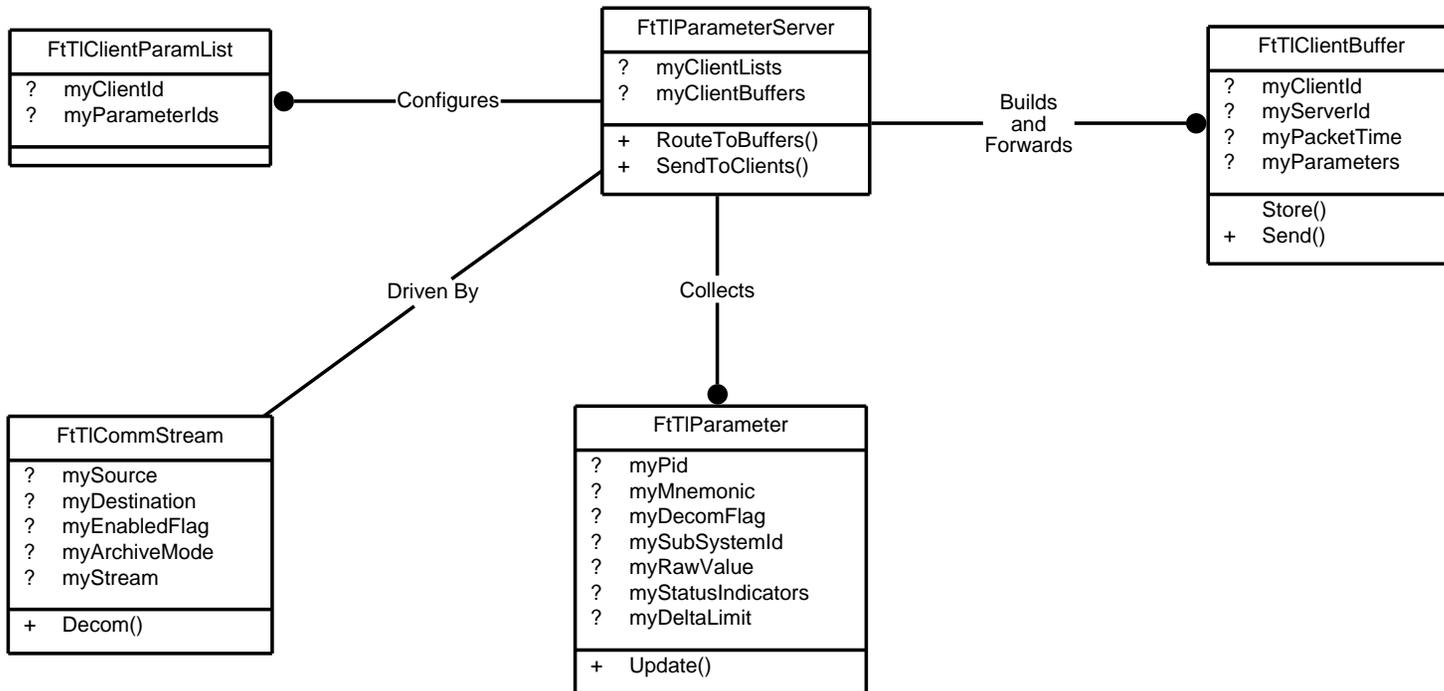
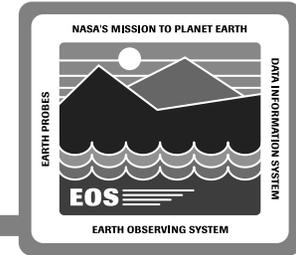
Collects user parameters

- **Client application buffer collects updated parameter values**
 - **Stores every telemetry update decommuted parameter derived parameter**
 - **Stores packet time stamp**
 - **Buffers allocated / assigned to each client application**

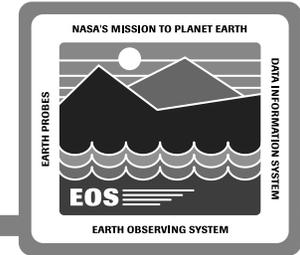
Distributes updated parameter values

- **Client buffer forwarded to specified application**
 - **Available following full processing of each packet**
 - **Forwarded once per packet**

Telemetry Distribution Object Diagram



Telemetry Distribution Scenario



Send updated parameter values to server (FtTIPParameterServer)

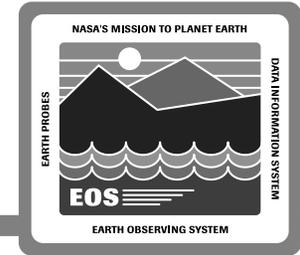
Determine if parameter is to be routed to any users

- **Compare parameter ID with those in the sets of user parameter lists (FtTIClientParameterList)**
- **Store parameter for user upon ID match (FtTIClientBuffer)**

Forward collected parameters to users

- **Following completion of EDU sampled and derived parameter processing (FtTICommStream)**

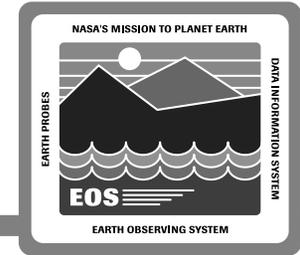
Telemetry Distribution Design Benefits



Consistent Telemetry Subsystem client interface

- **Internal client applications**
 - **Display**
 - **Analysis**
- **External client applications**
 - **Flight Dynamics Facility**
 - **Instrument team tools**
 - **New clients easily added via uniform interface**

Telemetry Distribution Design Benefits (cont.)



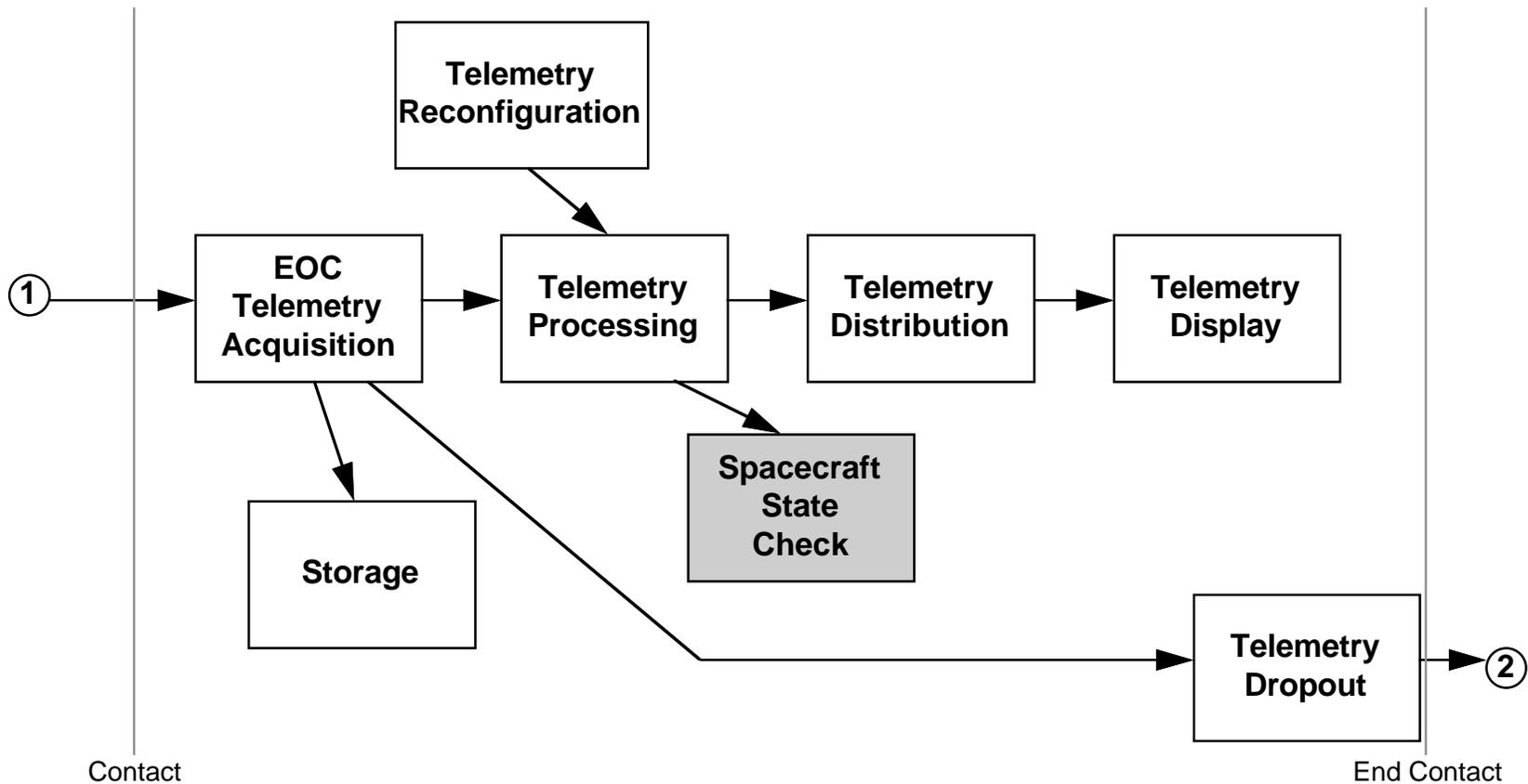
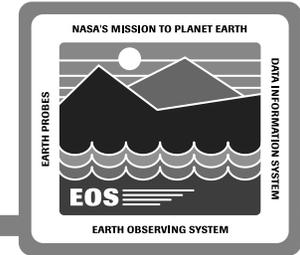
Flexible

- Telemetry processing / delivery loosely coupled
 - Could be on same machine, different machines
 - Client applications receive only what is of interest (e.g. CERES, MOPITT parameters)
 - selective decom
 - selective delivery

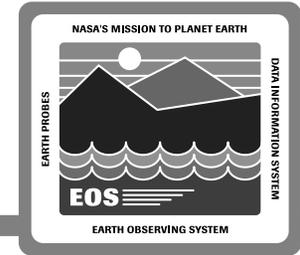
Potential compatibility / reuse

- Investigate TPOCC Data Server compatibility
 - Determine whether similar buffer format and protocol can be accommodated
- Investigate potential hooks to other GSFC products
 - GenSAA

Spacecraft State Check



Spacecraft State Check Overview



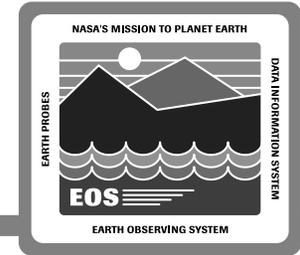
Spacecraft state check:

- **Verifies that the current state of the spacecraft is that which is expected**
- **Typically initiated via Ground Script directive**
 - **At beginning of each scheduled spacecraft contact period**

Expected state tables:

- **Built by Command Management during EOC Ground Script generation**
 - **Using knowledge of expected back orbit (non-contact period) commanded states**
- **Generated for each scheduled spacecraft contact**
- **Can be baselined during contact using current telemetry values**
- **Contain:**
 - **List of discrete telemetry parameter identifiers**
 - **Expected value of each parameter**

Spacecraft State Check Description



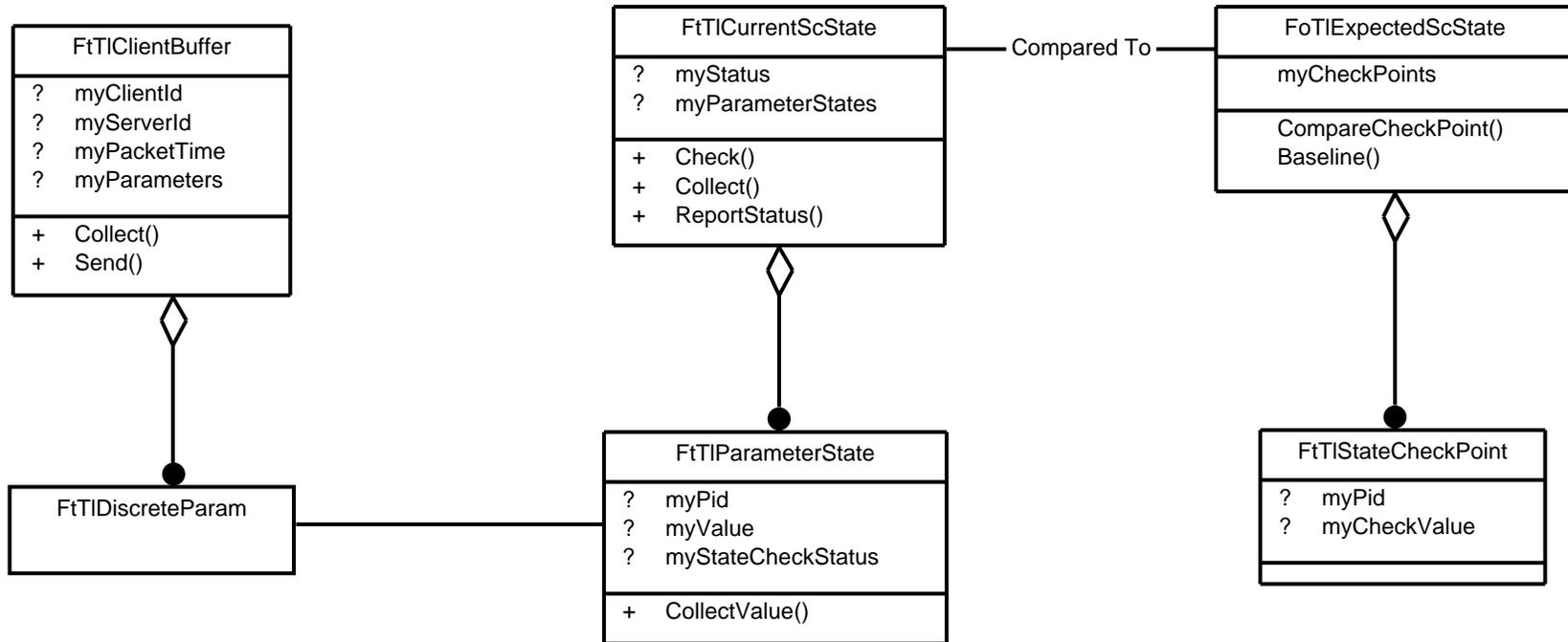
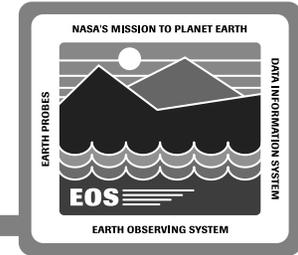
Determine current spacecraft state

- **Collect defined discrete parameter values**
 - Typically at beginning of each contact

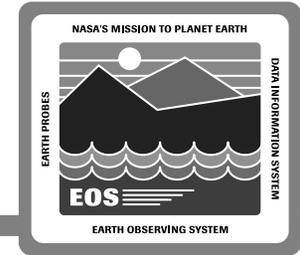
Compare current and expected states

- **Each collected parameter value checked against expected value**
- **Report state check status**

Spacecraft State Check Object Diagram



Spacecraft State Check Scenario



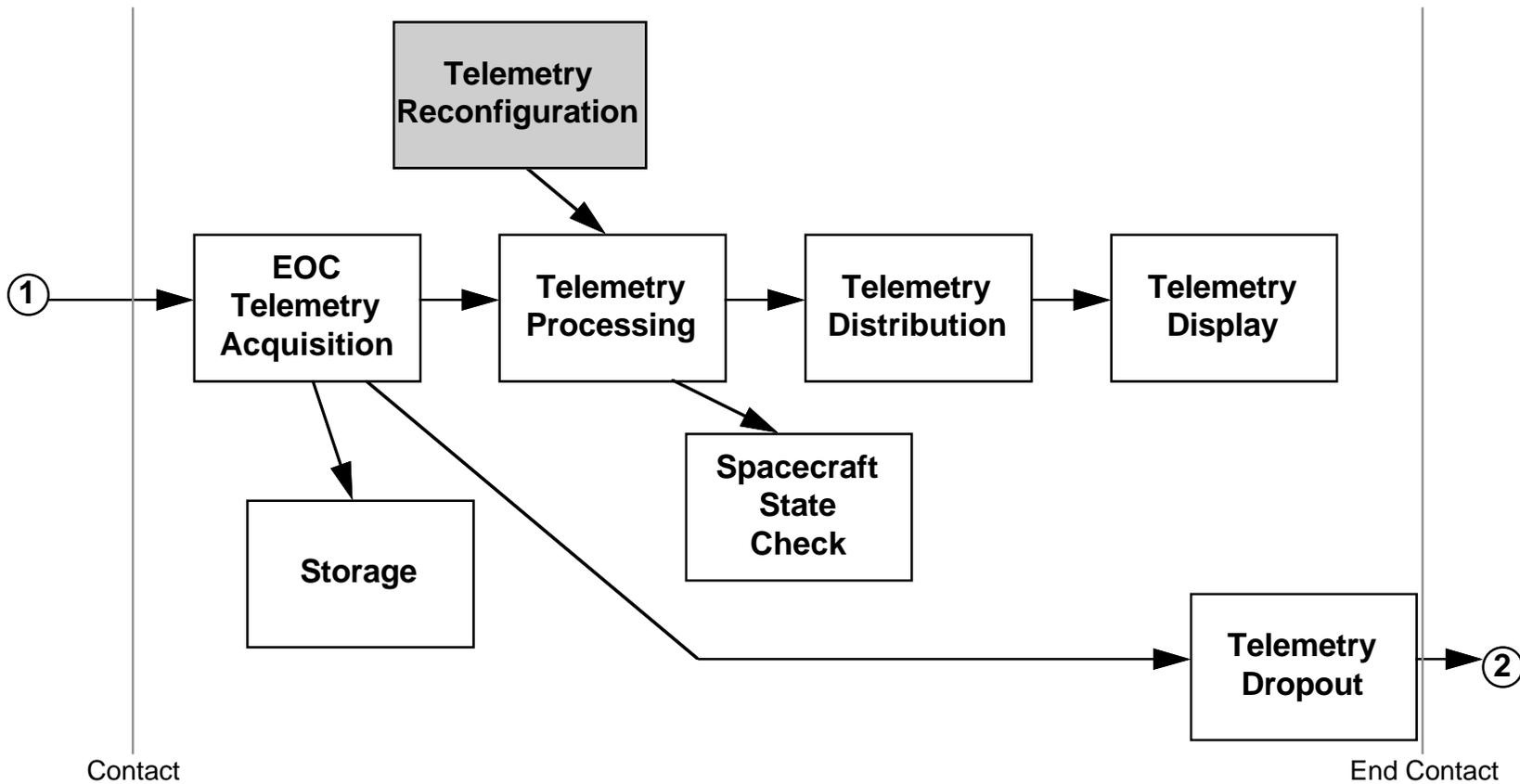
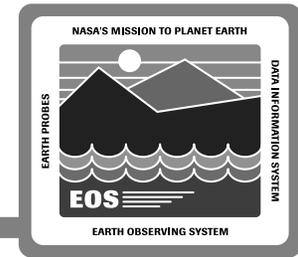
Receive a spacecraft state check request

- **Validate the request (FtTIConfigManager)**

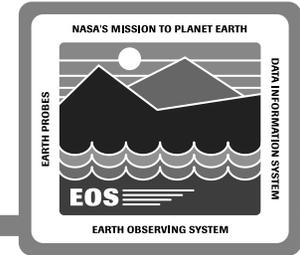
Process the state check request

- **Begin the spacecraft state check (FtTICurrentScState)**
 - **By collecting current values of good quality, predefined discrete parameters (FtTIDiscreteParam)**
- **Collect all state parameters (FtTIParameterState)**
- **Compare current spacecraft state against previously generated expected spacecraft state table (FoTIExpectedScState)**
 - **Using discrete check parameter values (FtTIStateCheckPoint)**
- **Update the status of each state check compare (FtTIParameterState)**
- **Report spacecraft state check status to users (FtTICurrentScState)**

Telemetry Configuration Change



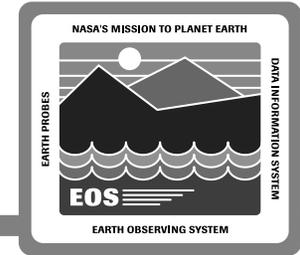
Telemetry Reconfiguration Overview



Configuration change modes

- **Comprehensive**
 - **RTS configuration changed by authorized user (under RMS control)**
- **Mirrored**
 - **RTS configuration change propagated to User Station**
- **Tailored**
 - **Configuration change isolated to User Station**

Telemetry Reconfiguration Description



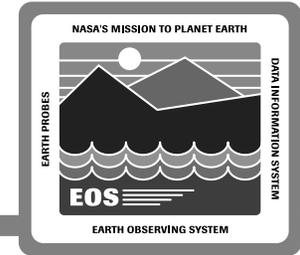
Receive configuration change request

Validate request

Adjust telemetry processing condition

Supply configuration change request status

Telemetry Reconfiguration Scenario



Receive a limit adjustment request

- **Validate the request (FtTIConfigManager)**

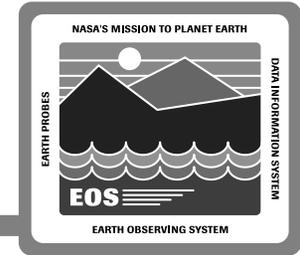
Process the limit change request

- **Update the limit value (FtTILimitSet)**
- **Determine status of limit change request**

Forward the reconfiguration status

- **For check-pointing and display (FoGnTImRmsIF)**

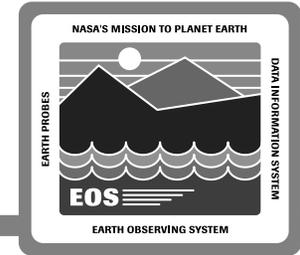
Telemetry Reconfiguration Design Benefits



Synchronized User Station configuration when in mirrored mode ensures:

- **Single point of telemetry configuration control**
- **Spacecraft subsystem and instrument engineers are observing and analyzing identically processed parameters**

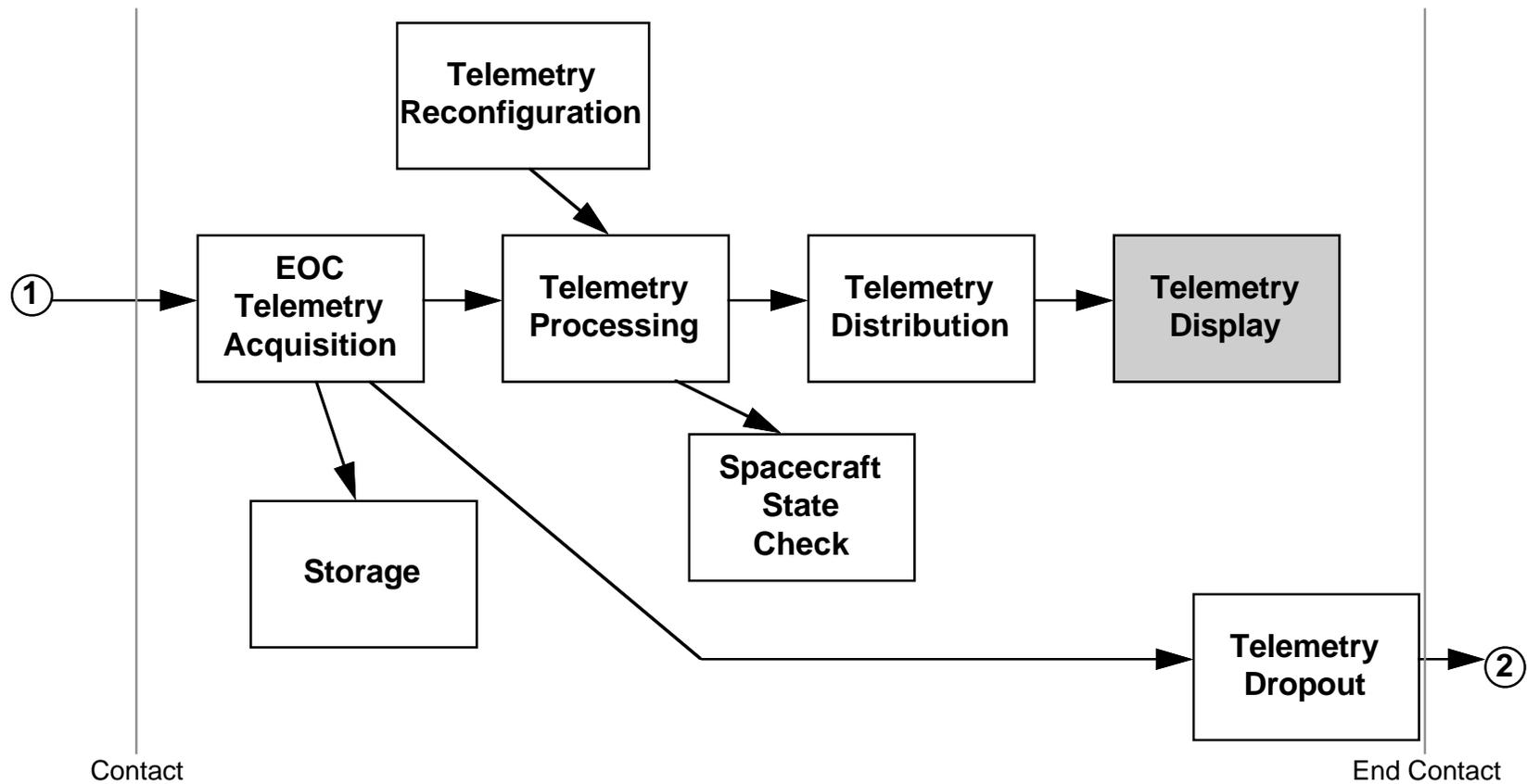
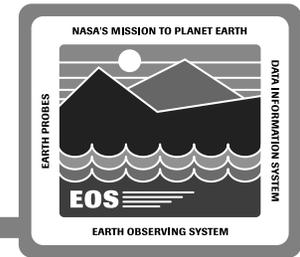
Telemetry Reconfiguration Design Benefits



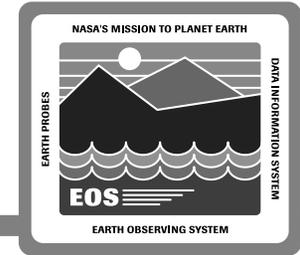
Customized User Station configuration when in tailored mode allows:

- **Spacecraft subsystem and instrument engineers to vary constraints**
 - **Tighten / loosen limit settings**
 - **Tighten / loosen sense intervals**
 - **Select specific EU conversion algorithm**
 - **Alter derived telemetry update rates**
- **Temporary and test configurations**
 - **Alterations can be verified prior to submittal to data base**

Telemetry Display



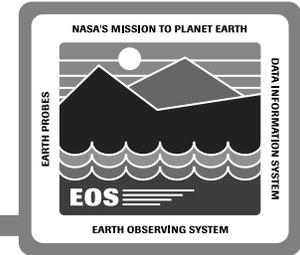
Telemetry Display Description



Display telemetry parameters on dynamic pages

- **Displays spacecraft telemetry, ground telemetry (user performance data, acquisition failure notification, CODA information), or analysis data sets**
- **Defined by the user via display builder**
- **Can generate its own page snap**
 - **Generates Encapsulated PostScript (EPS) file**
- **Composed of display items, labels, buttons and separators**
- **Receives parameter values from data source**
- **Can have more than one data source**
 - **Supports multiple parameters from multiple vehicles on the same page as alphanumeric, graph, table or schematic data**

Telemetry Display Description (cont.)



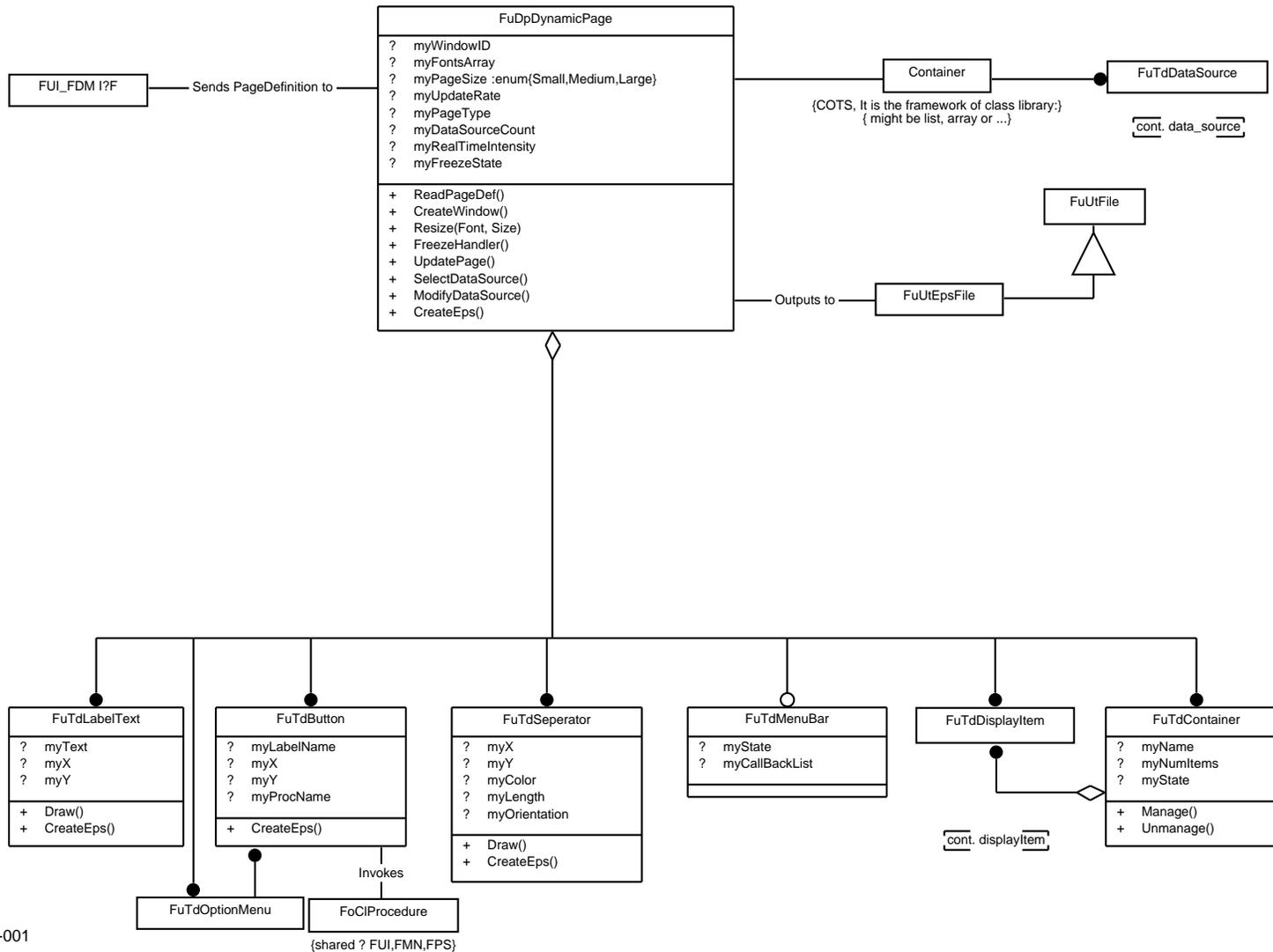
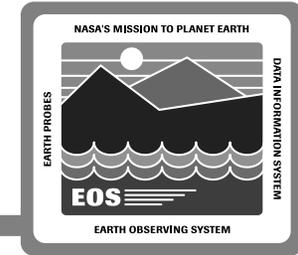
Data Source

- Associated with one logical string
- Contains all parameters required from that logical string
- Provides connection between the display item and the current values

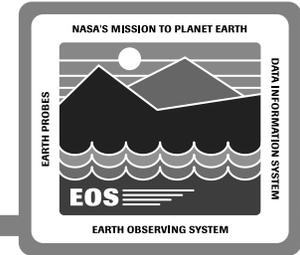
Display Item

- Associated with one or more parameters from one or more data sources
- Knows how to update itself
- Knows how to generate EPS

Telemetry Display Object Diagram



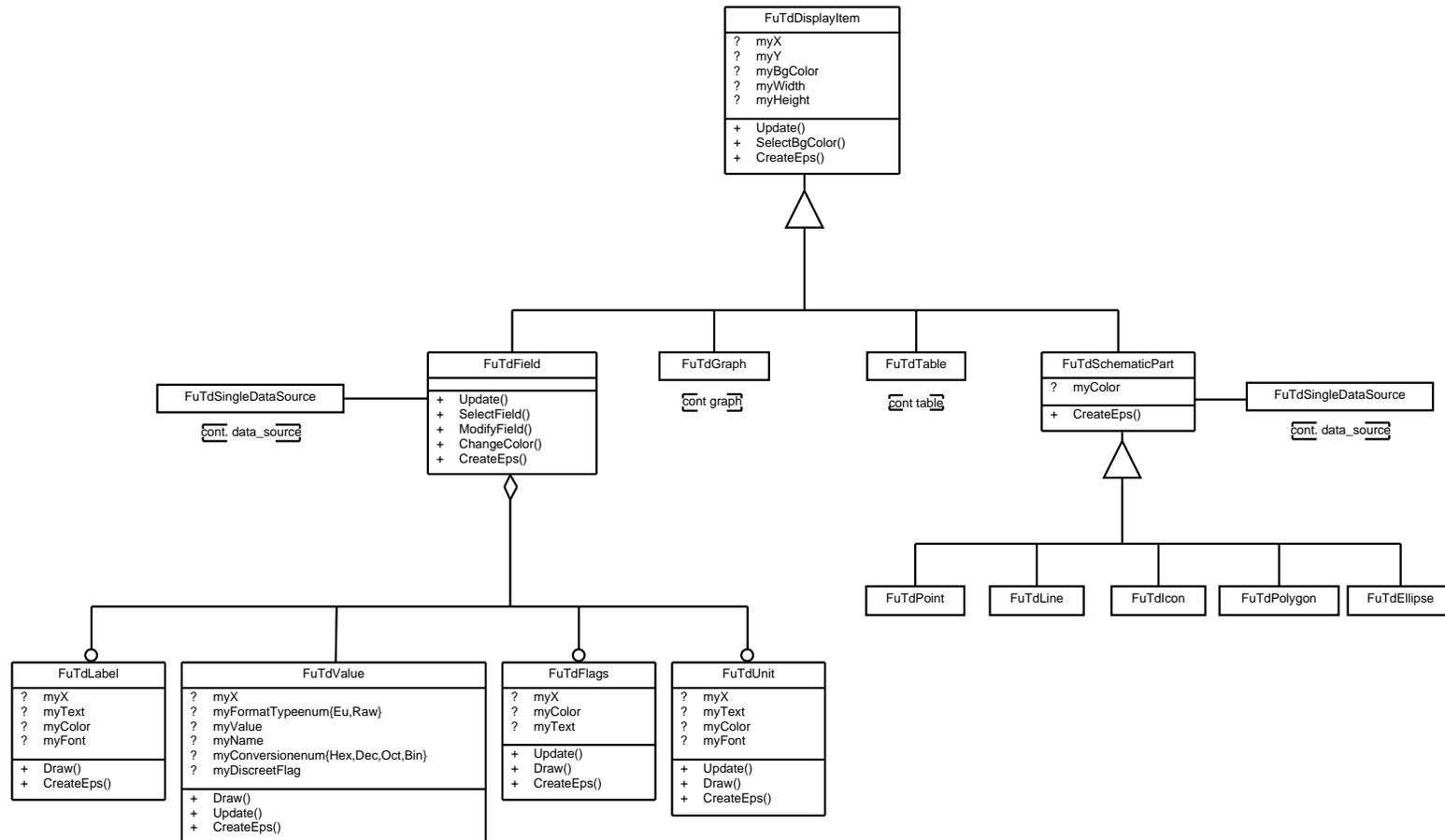
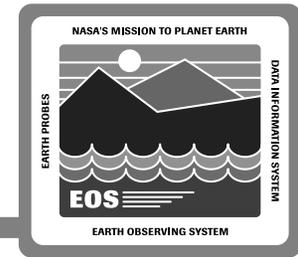
Telemetry Display Item Description



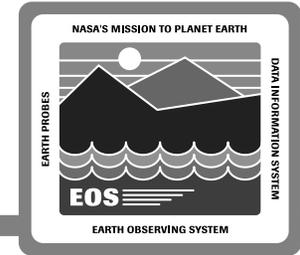
Display Item Types

- **Field (label, value, flag)**
 - Displays alphanumeric value
 - Contains one parameter from one data source
- **Graph (parameter vs. time, parameters vs. parameter)**
 - Displays real-time or historical data
 - Can contain more than one parameter from more than one data source
- **Table (spreadsheet like)**
 - Displays real-time or static data
 - Can contain more than one parameter from more than one data source
- **Schematic (point, line, ellipse, polygon, icon)**
 - Displays spacecraft subsystems or data/procedure flows
 - Contains one parameter from one data source

Telemetry Display Item Object Diagram



Telemetry Display Creation Scenario



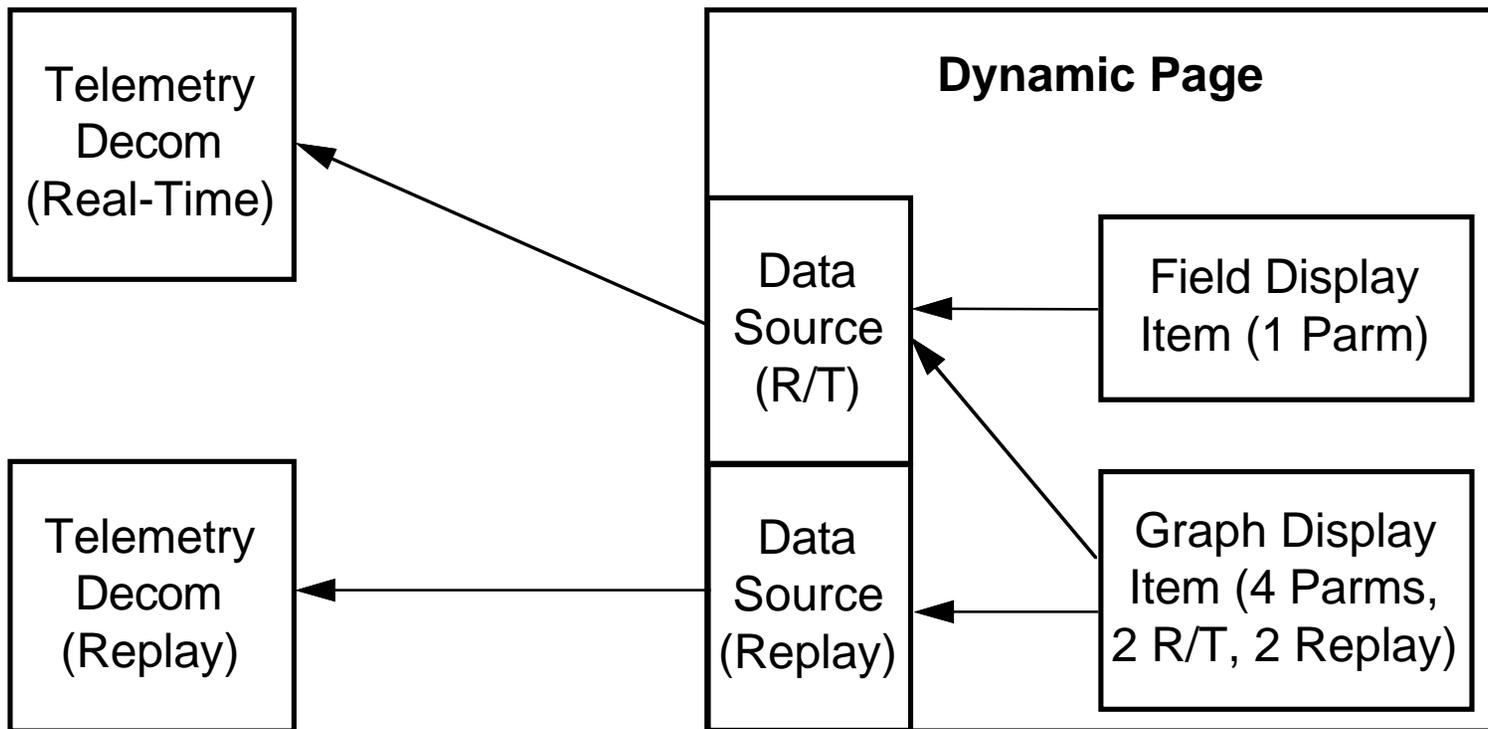
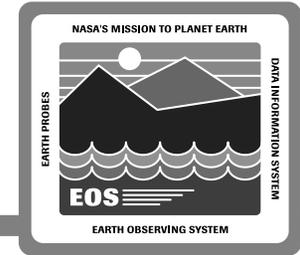
Dynamic page containing one field and a graph of 2 pairs of parameters

- **Parameter pairs are identical**
- **One pair from real-time data source, the other from replay**

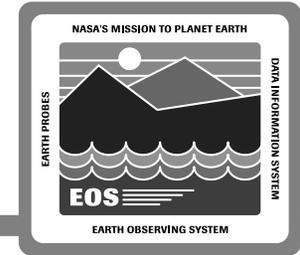
Creation

- **At initialization the dynamic page creates 2 data sources**
- **The data sources connect to the associated logical string, specified in the data-base, and register all parameters of interest**
- **The dynamic page creates all display items (one field and one graph)**
- **The display items load formats from the data-base and link to the appropriate data source(s)**

Telemetry Display and Data Sources



Telemetry Display Update Scenario

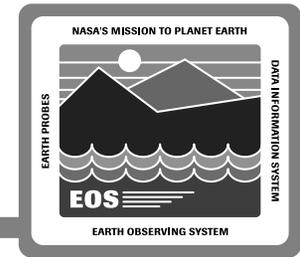


The dynamic page issues the update command to the display items

Each display item queries the data source for its value(s) and performs the necessary steps to update itself

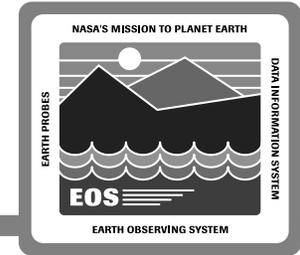
- **Alphanumeric updates current values and sets any limit/quality flags**
- **Graphs scrolls y-axis and adds new line segments**
- **Table scrolls time and data columns and adds new current values**
- **Schematic changes color/icon depending on current value**

Prototype Telemetry Displays



Available in hardcopy only.

Telemetry Display Design Benefits



Data from multiple sources on the same display

- **Real-Time and/or replay and/or historical**
- **Different vehicles**

Alphanumeric, graph, table and schematic data on the same page

- **Allows user to view same data different ways**

Encapsulated PostScript generates high quality output

- **Can be imported into COTS word processing or graphics packages**

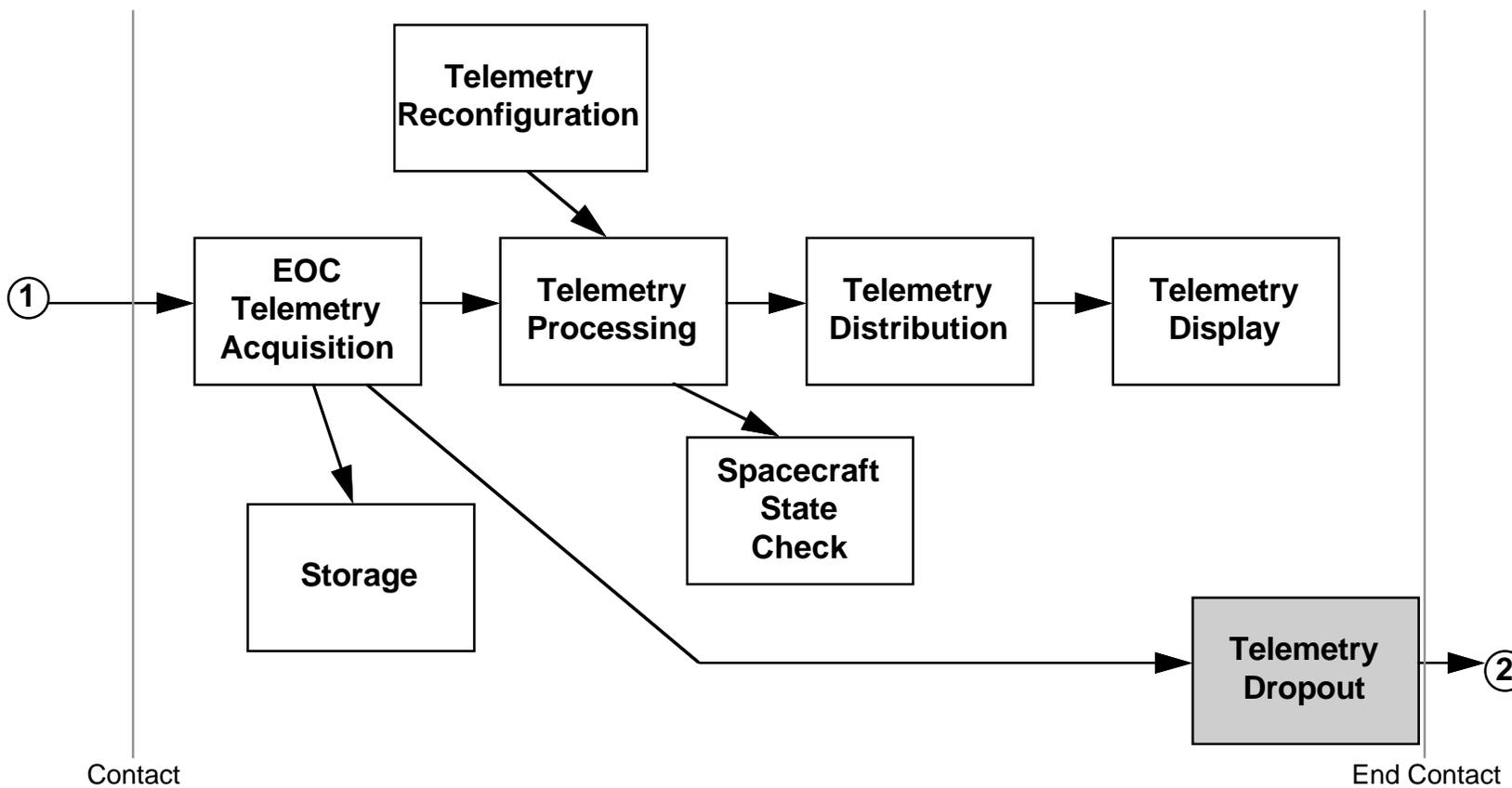
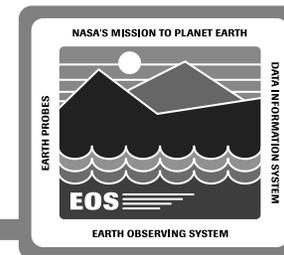
Graphs and tables are also used to display off-line analysis data

- **User only needs to learn one interface**

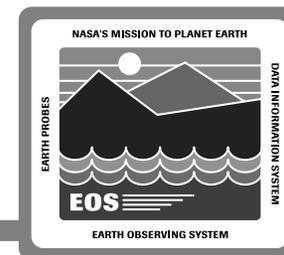
User definable pages

- **Allows for easy customization and growth**

Telemetry Dropout



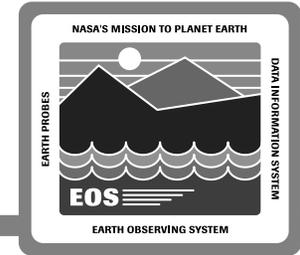
Telemetry Dropout Description



Detect loss of telemetry

- **Data dropout**
 - **End of contact**
 - **Communication link severed**
 - **Spacecraft anomaly**
- **Use expected EDU reception time interval**
 - **Elapsed interval indicates loss of telemetry**

Telemetry Dropout Description (cont.)



Mark telemetry parameters

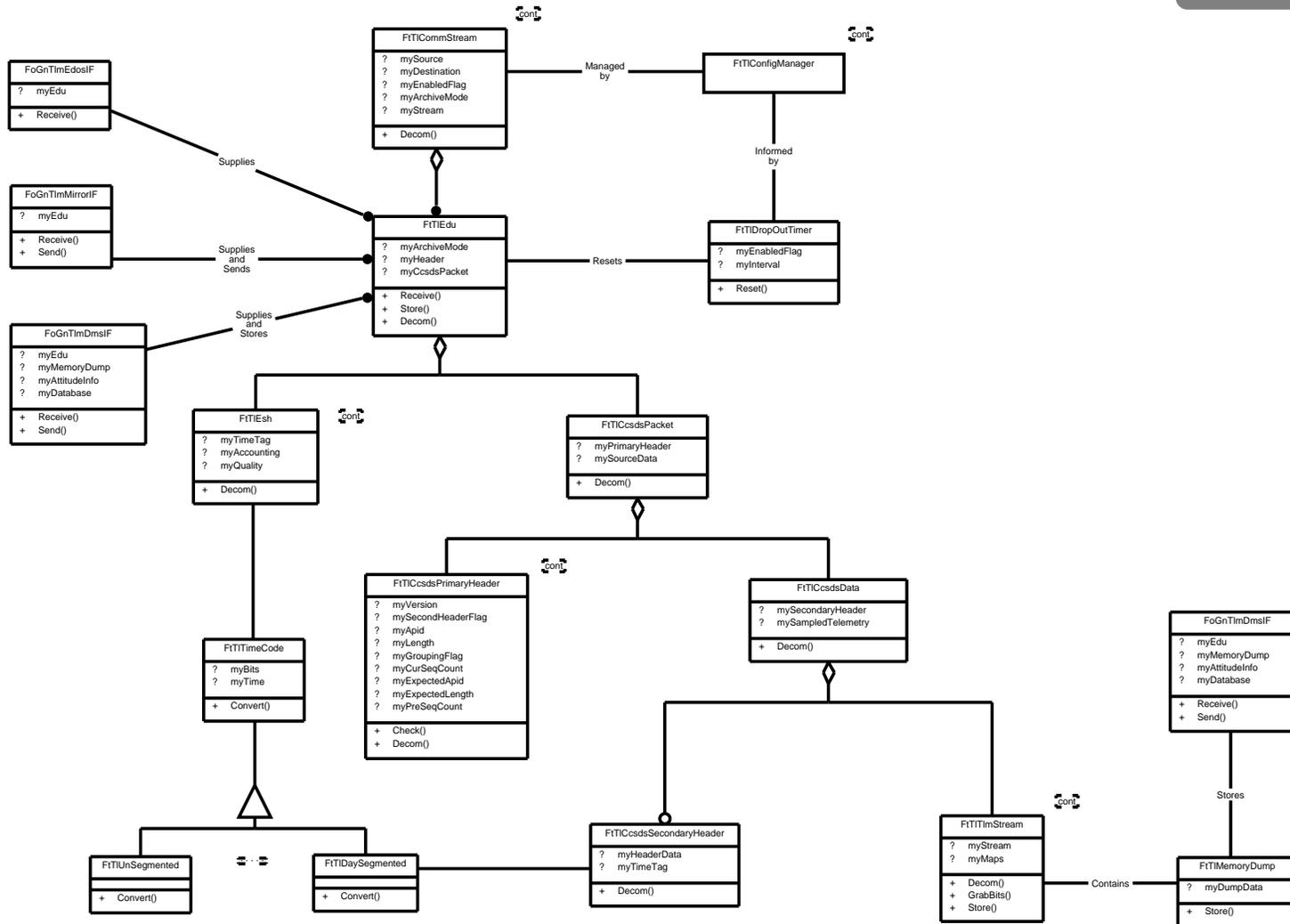
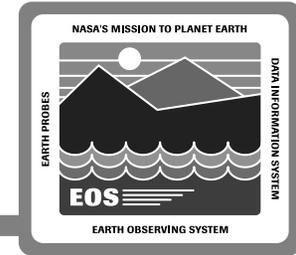
- Active while EDU reception continues
- Static when dropout has been detected

Key Terms:

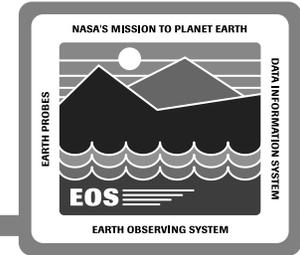
Active - parameter state status which indicates that the telemetry parameter is being updated.

Static - parameter state status which indicates that a telemetry parameter is not currently being updated.

Telemetry Dropout Object Diagram (1 of 2)



Telemetry Dropout Scenario



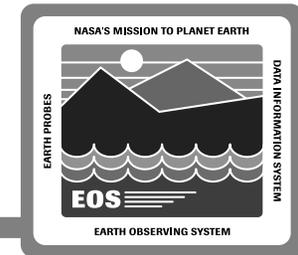
Receive an EDU

- **No data dropout indicated**
 - **Dropout detector reset (FtTIDropoutTimer)**

Miss an EDU

- **Data dropout indicated**
 - **Dropout detector triggered**
 - time between EDUs greater than expected (timer elapsed)**
 - **Report the loss of telemetry condition to users (FtTIConfigManager)**
 - **Mark parameters static (FtTIConfigManager)**

Real-Time Scenario Contact (cont.)



Pre-Contact

- System Initialization
- User Connection
- Command Authority Request
- Ground Script Initialization
- NCC Communications Test
- EDOS Communications Test

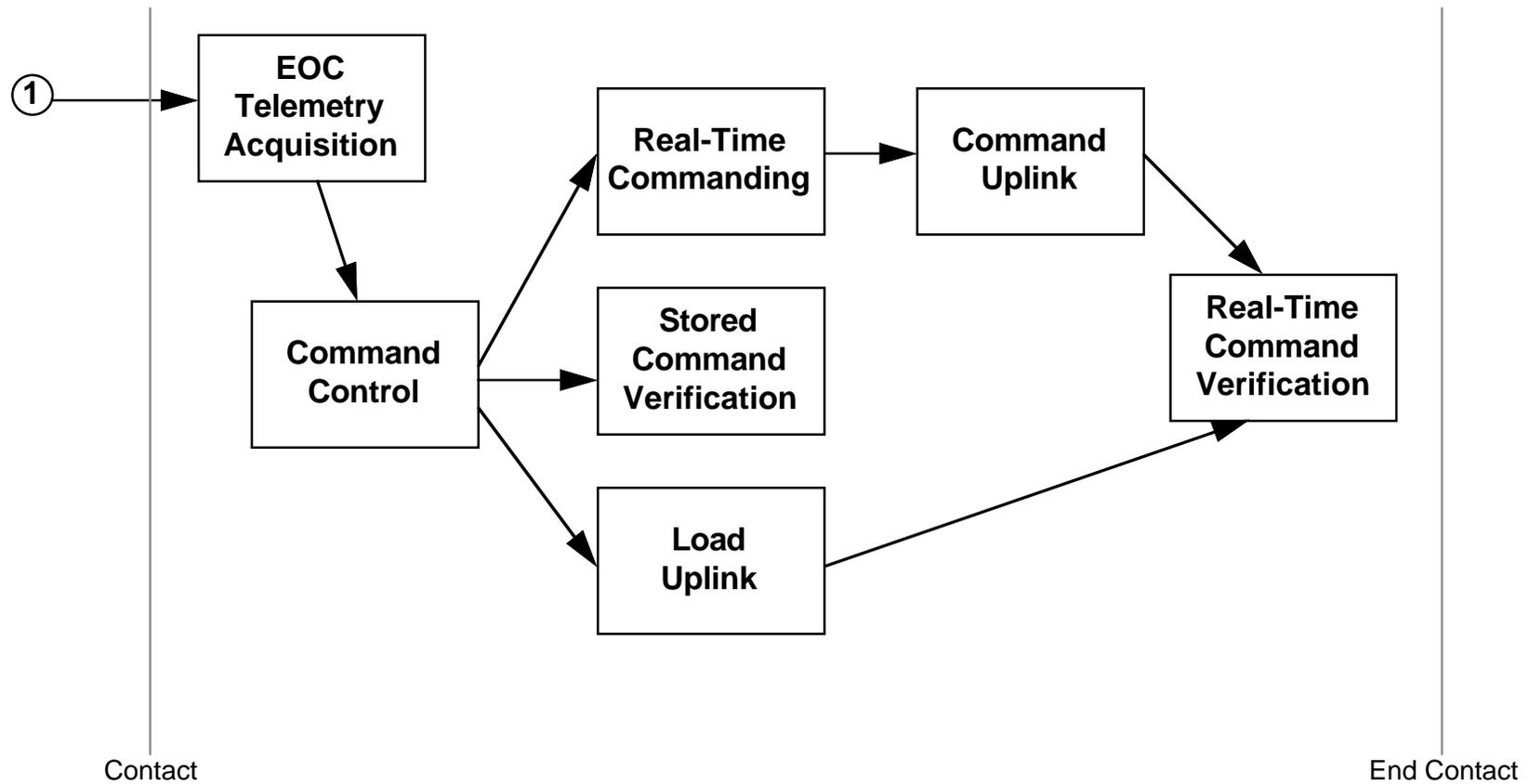
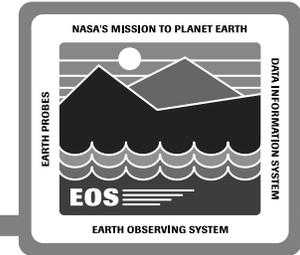
Contact

- Ground Telemetry Processing
- Spacecraft Telemetry Processing
- Spacecraft Commanding

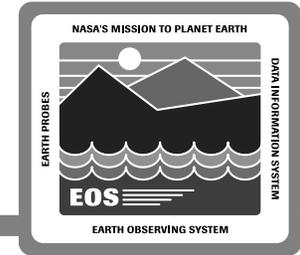
Post-Contact

- Spacecraft Telemetry Playback
- Spacecraft Telemetry Merge
- Statistics Generation

Real-Time Scenario Contact (cont.)



Real-Time Scenario Contact Overview (cont.)



Command Control

- allows the user with command authority
 - to transmit spacecraft commands/loads
 - to configure the EOC command capability

Real-Time Commanding

- Generation and validation of real-time commands

Command Uplink

- Transmission of real-time commands

Real-Time Command Verification

- Real-time command execution verification via telemetry

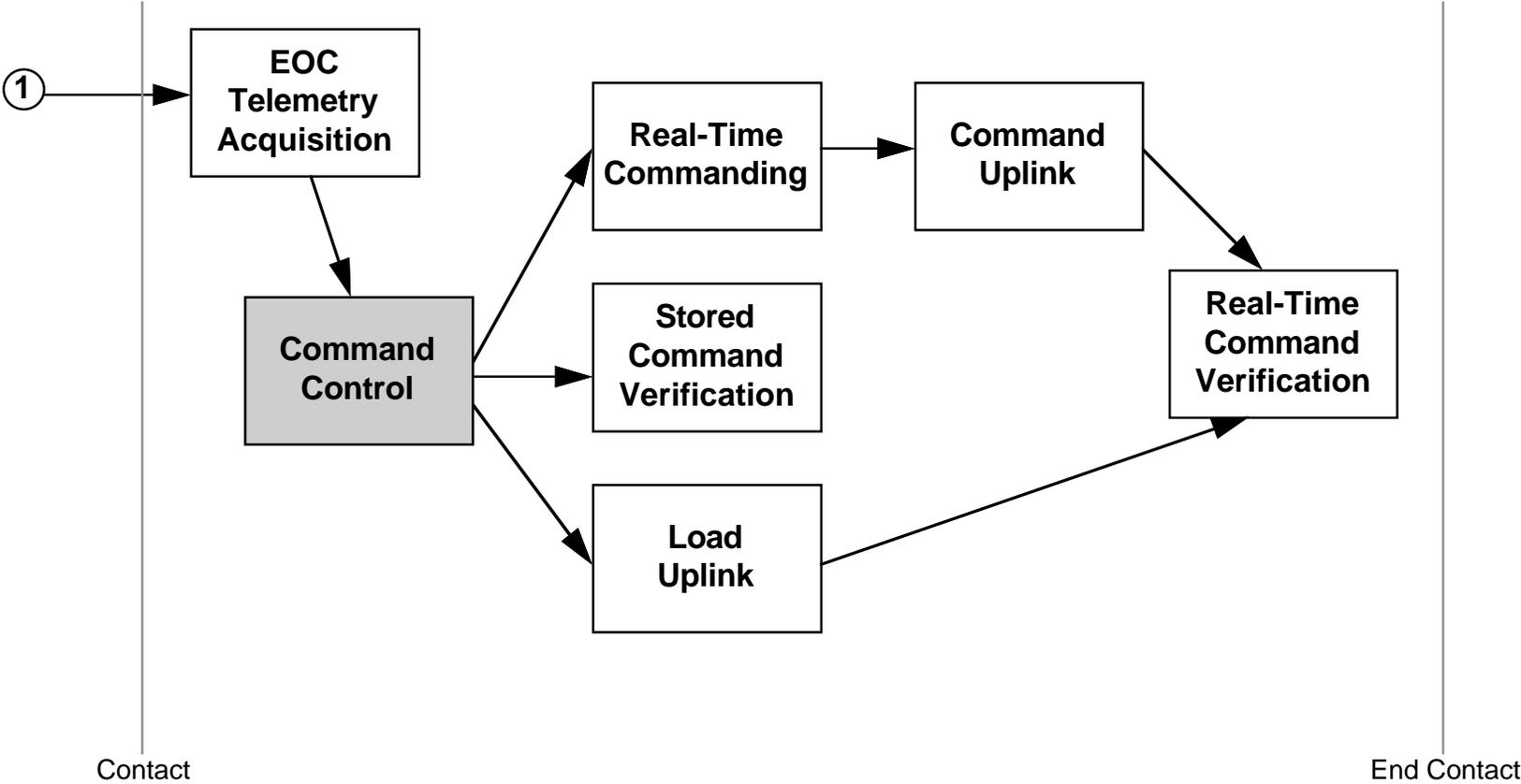
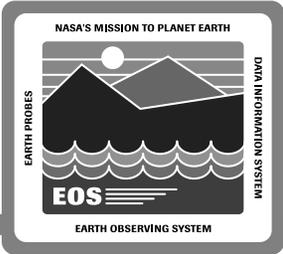
Load Uplink

- Transmission of spacecraft and instrument loads

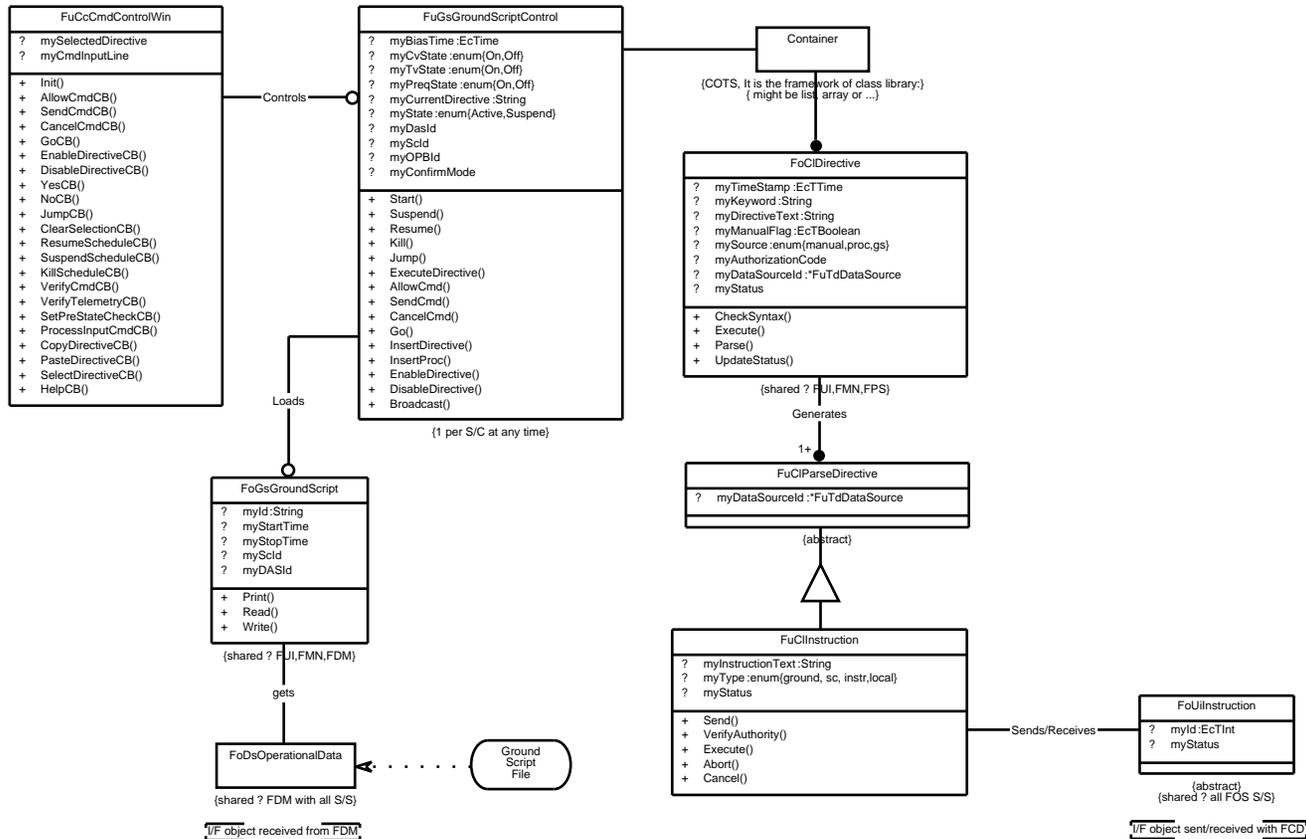
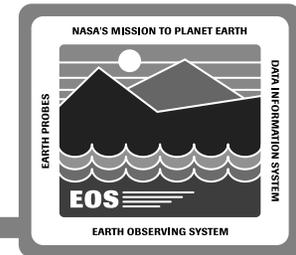
Stored Command Verification

- Stored command execution verification via telemetry during a contact

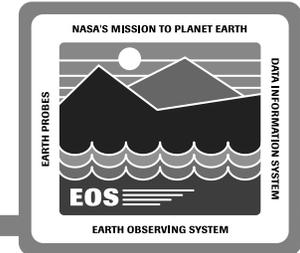
Command Control



Command Control Object Diagram

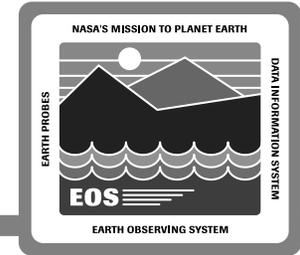


Command Control Description



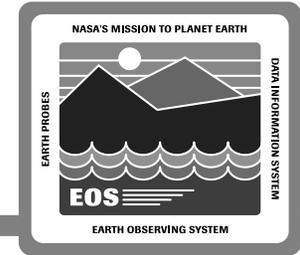
- **Command Control Window is displayed on the Operator's workstation**
- **Ground script is active**
- **Capability of controlling ground script**
 - **Suspend/Resume execution of the ground script**
 - **Enable/Disable directives in the ground script**
 - **Transfer execution to a selected directive (Jump)**
- **Capability of controlling command checking**
 - **Enable/Disable command verification**
 - disable allows script to continue - uplink is ALWAYS verified**
 - **Enable/Disable telemetry verification**
 - disable allows script to continue - execution is still verified**
 - **Enable/Disable prerequisite state check**

Command Control Scenario



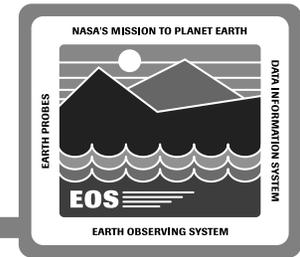
- **Each directive is executed at its scheduled time**
- **Command directive is sent to the Command Subsystem via an interface object (FoUilnstruction)**
- **Status is received from the Command Subsystem**
- **Status is displayed for each directive**

Command Control Design Benefits

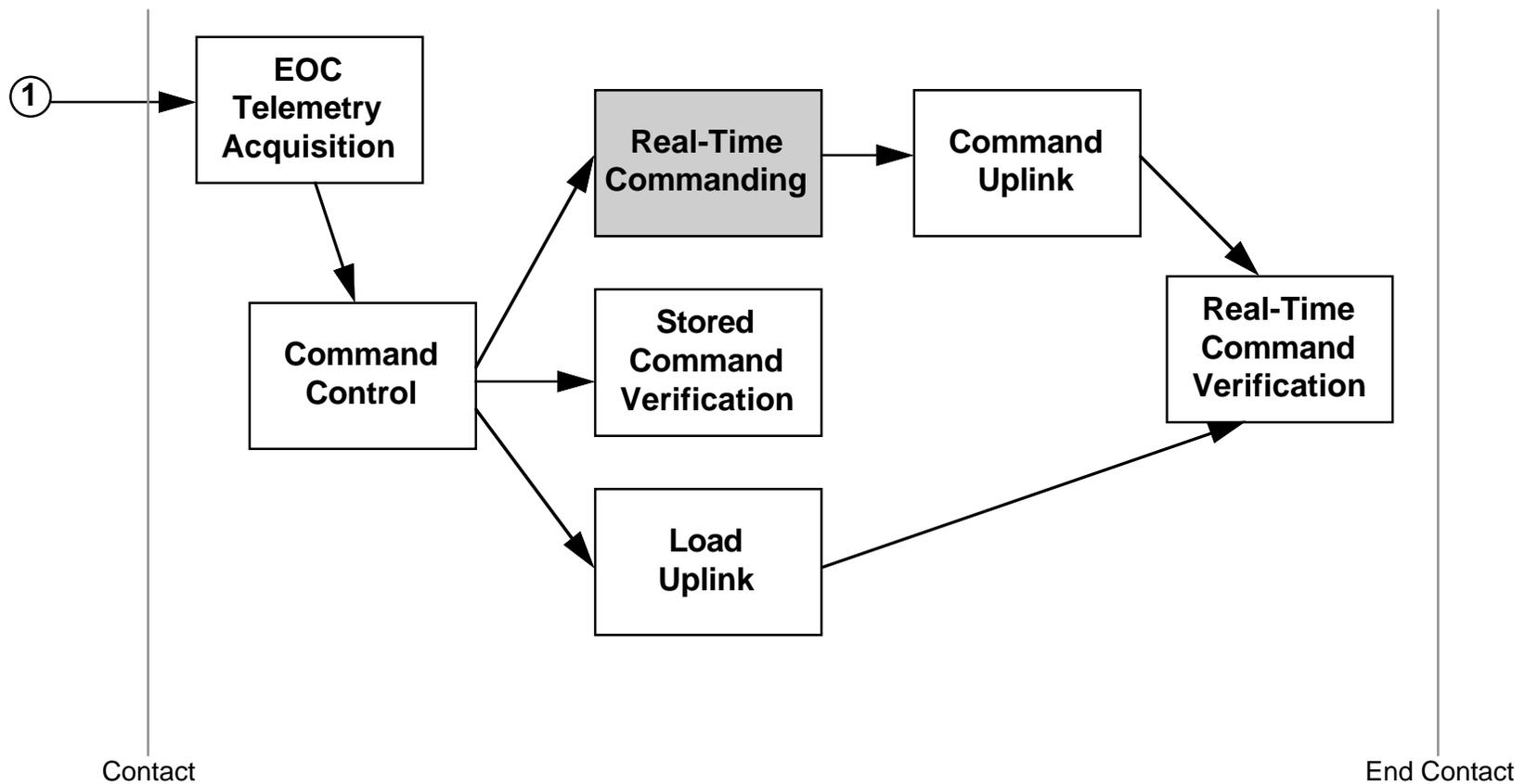
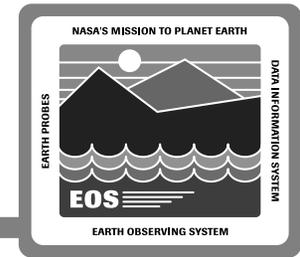


Ground Script provides automation of preplanned commanding activities

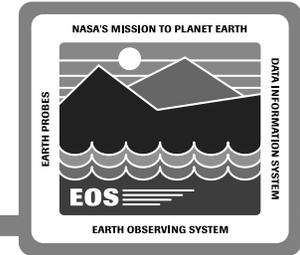
Command Control Display



Real-Time Commanding



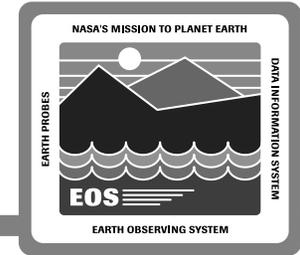
Real-Time Commanding Description



Command processing “Controller”:

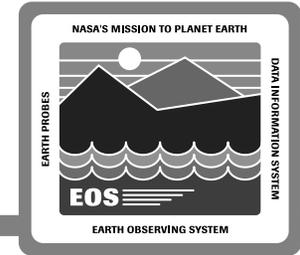
- **Initializes Command Subsystem for a single spacecraft contact**
- **Controls flow of operations to process commands**
 - **Validation**
 - **Generation**
 - **Transmission**
 - **Verification**

Real-Time Commanding Description (cont.)



- **Initializations for each command processed**
 - **Initializes items needed for validation of the command**
 - **Initializes items needed for generation of the command**
 - **Initializes command's verification modes**
- **Notifies Command Management subsystem of successful memory load**
- **Command status for ASTER commands exported to ASTER ICC (FoGnCmdIplccIF)**
- **Command status exported to FOT and ISTs via User Interface**
- **(all above provided by FcCdCmdController, FcCdRtCmdController)**

Real-Time Commanding Description (cont.)



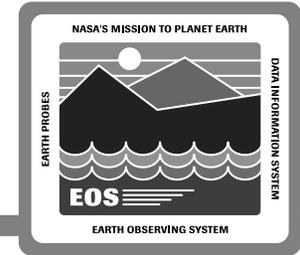
Provisions for command definitions:

- **Command definitions for a single spacecraft and its instruments**
- **Initialized from the Data Management Subsystem**
- **Command definitions used in the validation and verification of command directives**
- **(all above provided by FcCdCommandDatabase)**

Command processing:

- **Responsible for building the binary bit pattern for uplink**
- **Prerequisite state checking and telemetry verification**
- **Operator prompt for critical commands**
- **(all above provided by FcCdCmdController, FcCdRtCmdController)**

Real-Time Commanding Scenario



COMMAND VALIDATION SCENARIO:

Command directive is forwarded by FOS User Interface subsystem

Checks for load command (determines that it is NOT a load command)

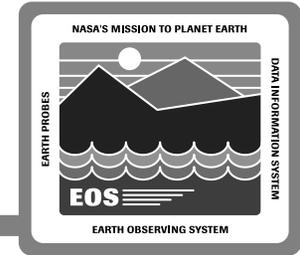
Compares ID of the issuer of the command with ID of Operator who has command authorization

Accesses and retains validation and verification information (within FcCdRtCmd)

Initiates validation: (FcCdRtCmd)

- Checks the ID of the issuer of the command against valid users of the command
- Check / supply submnemonics (as needed)
- Check prerequisites (up to four telemetry points)
- Issues a critical prompt for the Operator to respond allow or cancel

Real-Time Commanding Scenario (cont.)



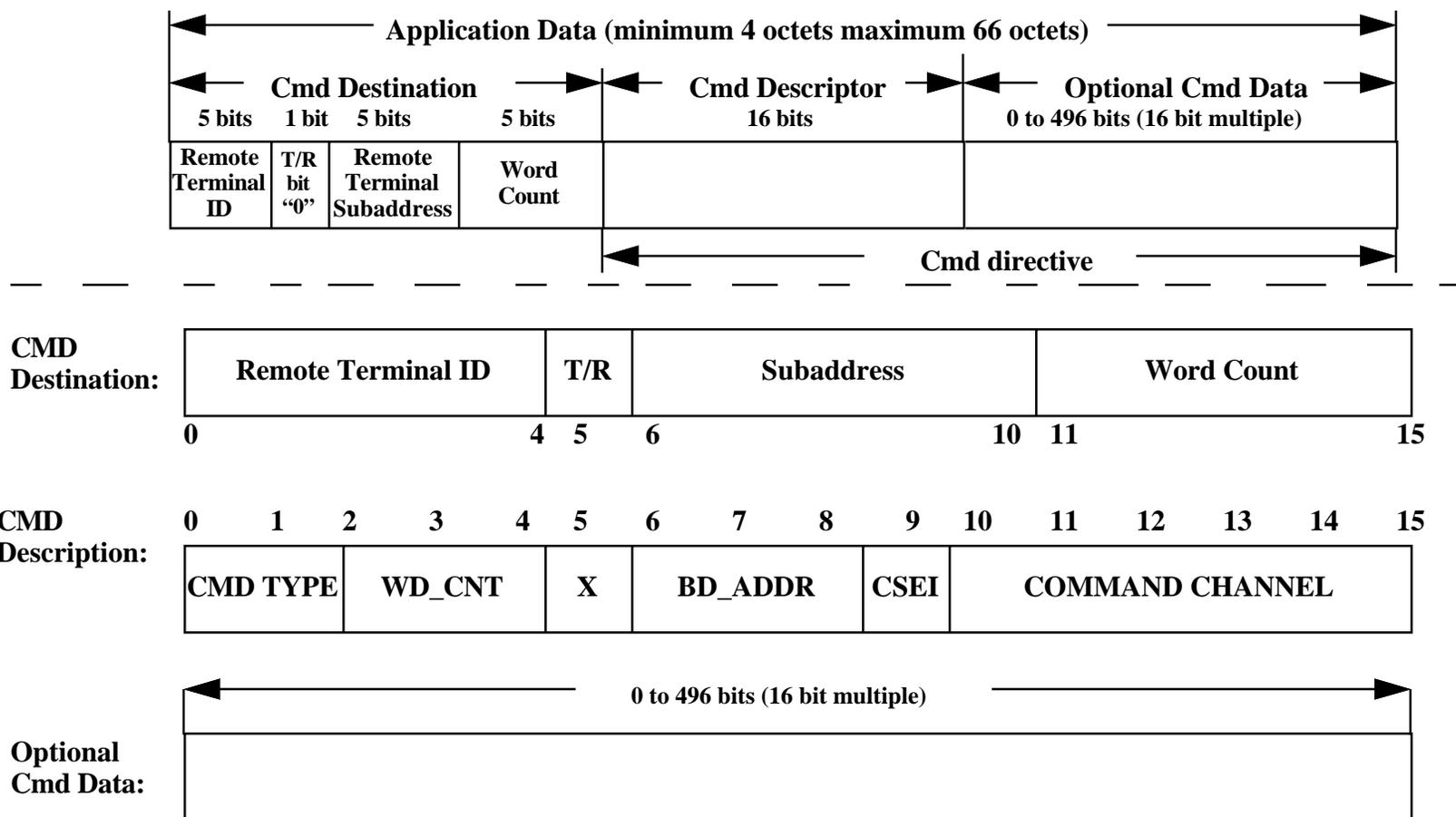
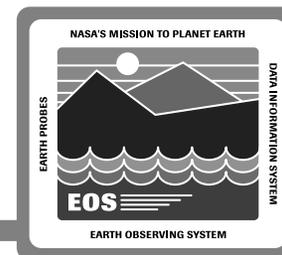
COMMAND GENERATION SCENARIO: (specific to the AM-1 mission)

A command is Built, in 1553-B format: (FcCdRtCmd)

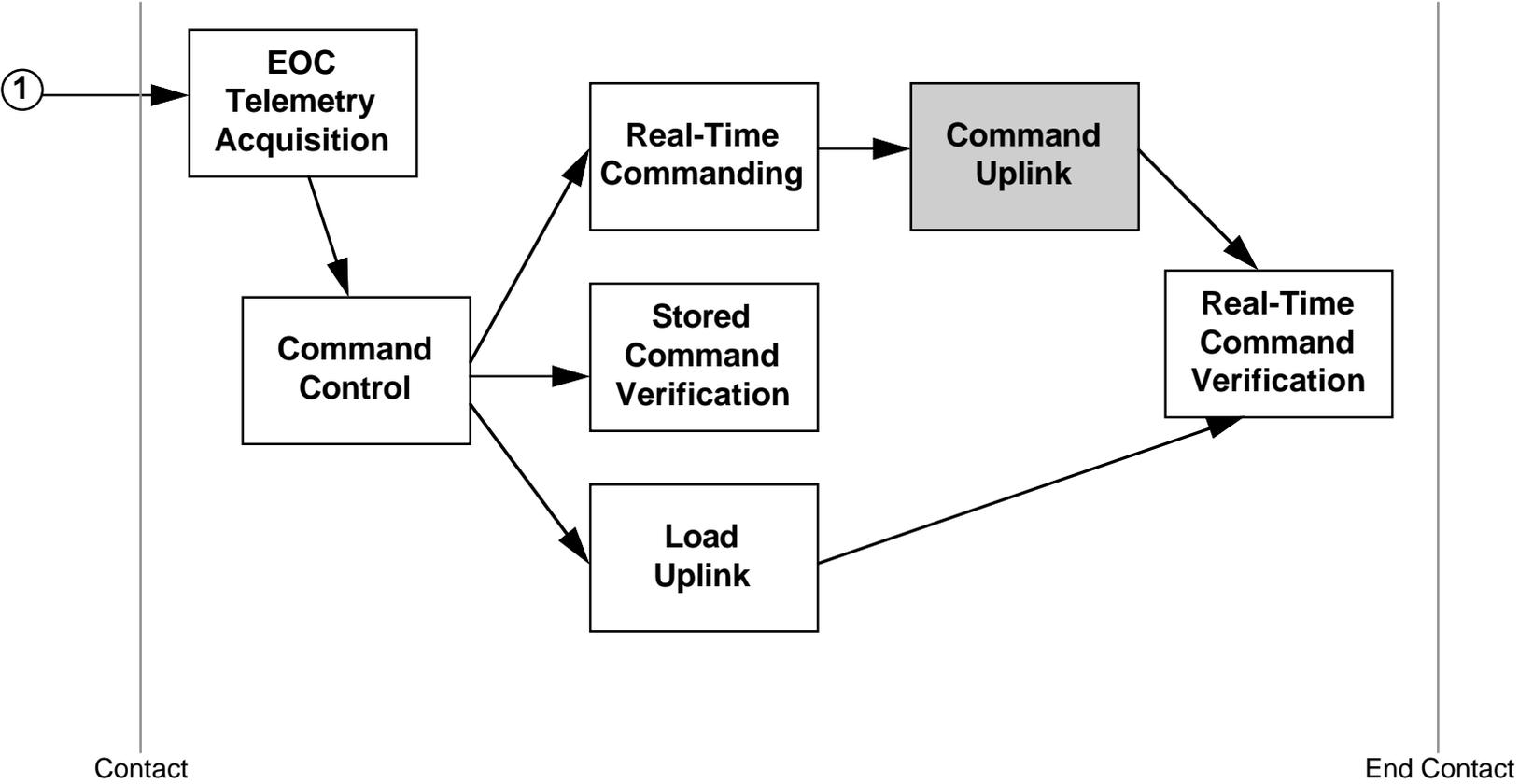
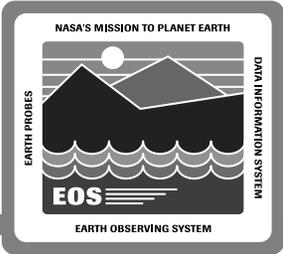
- **Command destination: Remote Terminal ID, Subaddress, Word Count**
- **Command Descriptor: Command Type, Word count, Board address, Channel select, Command Channel**
- **Command data: user defined, or database defined**
 - **Optional, per command**
 - **User specifies via submnemonics**

Completed Command is Sent back to the "Controller"

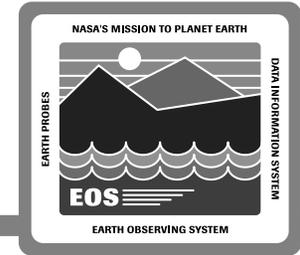
AM-1 Application Data (1553-B Format - BDU Command)



Command Uplink



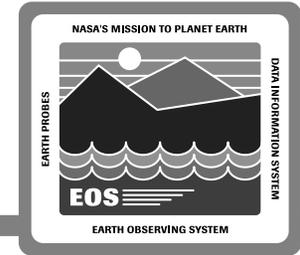
Command Uplink Description



CCSDS protocol formatting

- **CCSDS Data Management Service provided**
 - 1553-B command encapsulated into CCSDS packet
- **CCSDS Data Routing Service provided**
 - CCSDS packet encapsulated into CCSDS transfer frame
- **CCSDS Channel Service Provision ***
 - CCSDS transfer frame encapsulated into CLTU
 - CLTU frames are queue for later retransmission if needed
- (all above provided by FcCmCCSDSFop, FcCmTcFrame)
- **NOTES:**
 - The AM-1 spacecraft does not utilize the segment layer; therefore there is no provision for Frame Data Units (FDUs)
 - EDOS implements Physical Layer Operations Procedure (PLOP):

Command Uplink Description (cont.)



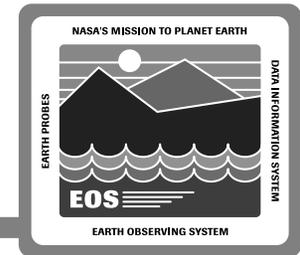
Includes acquisition sequence

Includes idle patterns

COP-1 processing coordination -

- **Verifies onboard receipt of commands**
 - **Processing of CLCWs provides verification status**
- **Automatic retransmission upon detection of missed or compromised command**
- **FOP (Frame Operation Procedure) processing support**
- **FARM (Frame Operation Reporting Mechanism) control**
 - **Processing of BC (bypass control) type frames, provides for:**
 - UNLOCK**
 - MODIFY (next expected frame seq.#)**
 - SET (next expected frame seq.# to zero)**
- **(all above provided by FcCmCCSDSFop, FcCmTcFrame)**

Command Uplink Scenario



Example of 5 commands being uplinked

“PROCESSING” notation is used for iteration purposes

- **PROCESSING** is detailed in later slides

3 commands issued before any “uplink” is acknowledged

- **The UPLINK PROCESSING** is repeated three times

Two commands ack'd between uplinking of the 3rd & 4th

- **CLCW seq.#** has increased by 2
- **ACKNOWLEDGMENT PROCESSING** is repeated twice

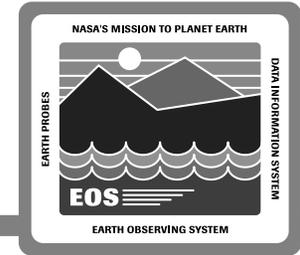
Last 2 commands (the 4th & 5th) are uplinked

- **UPLINK PROCESSING** repeated twice to process two commands

Last 3 commands are ack'd after the 5th is uplinked

- **CLCW seq.#** has increased by 3
- **ACKNOWLEDGMENT PROCESSING** is repeated 3 times

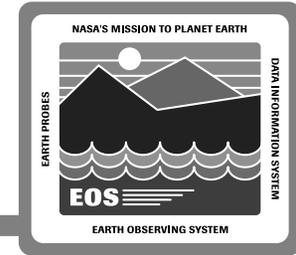
Command Uplink Scenario (cont.)



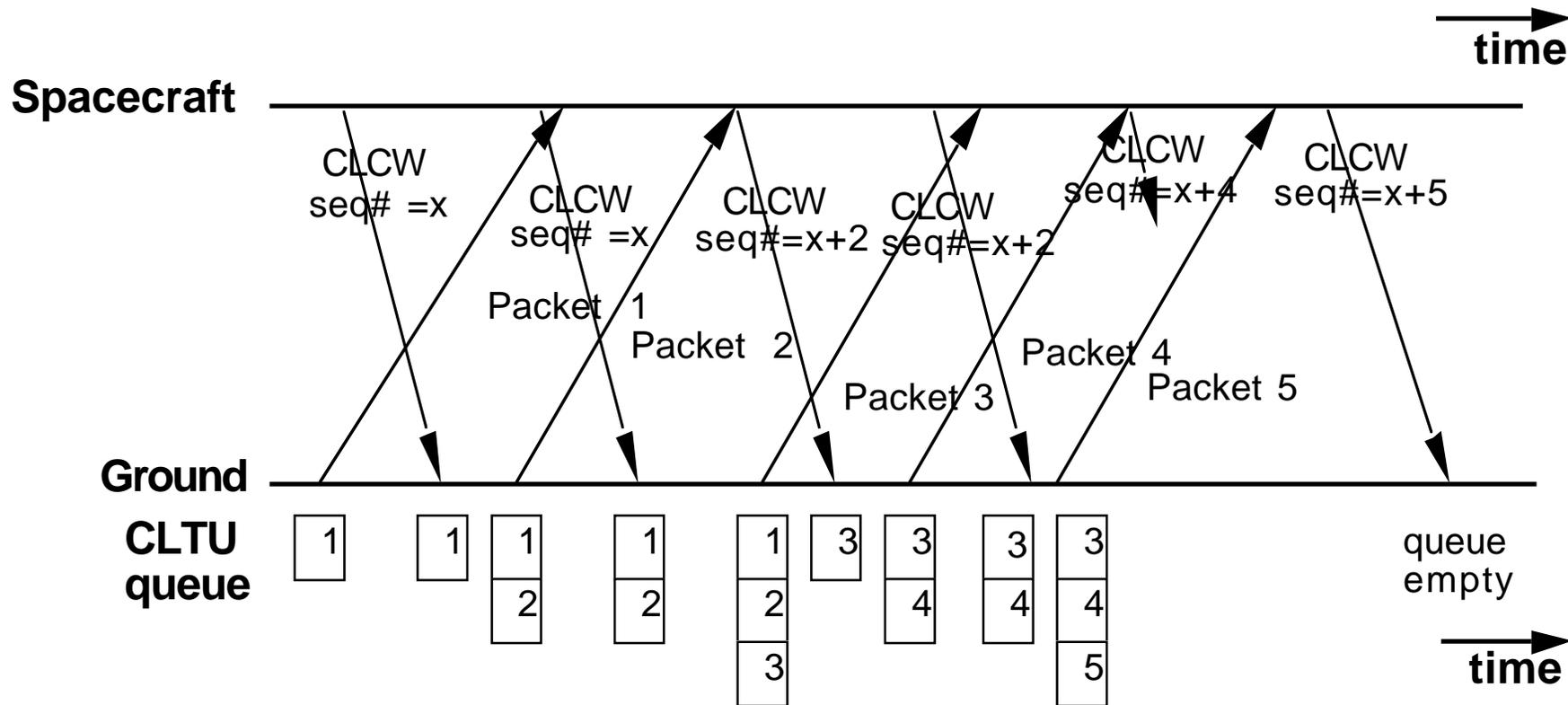
Command Uplink Scenario Sequence of Events:

EVENT	ACTION	OUTSTANDING COMMANDS (QUEUE SIZE)
CAC issues 1st cmd	Do: "UPLINK PROCESSING"	1st cmd (1)
CLCW seq. number unchanged	none	1st cmd (1)
CAC issues 2nd cmd	Do: "UPLINK PROCESSING"	1st & 2nd cmds (2)
CLCW seq. number unchanged	none	1st & 2nd cmds (2)
CAC issues 3rd cmd	Do: "UPLINK PROCESSING"	1st, 2nd & 3rd cmds (3)
CLCW seq. number changed; +2	Do: "ACK. PROCESSING" (twice)	3rd cmd (1)
CAC issues 4th cmd	Do: "UPLINK PROCESSING"	3rd & 4th cmds (2)
CLCW seq. number unchanged	none	3rd & 4th cmds (2)
CAC issues 5th cmd	Do: "UPLINK PROCESSING"	3rd, 4th & 5th cmds (3)
CLCW seq. number changed; +3	Do: "ACK. PROCESSING" (three times)	no outstanding cmds (0)

Command Uplink Scenario (cont.)

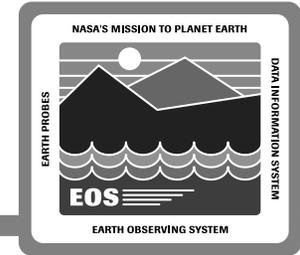


Command Uplink Scenario Illustration of Events:



Notes: 'x' equals the value of the CLCW sequence number at the beginning of the scenario. The transmission of the 5th CLCW is unsuccessful (incomplete).

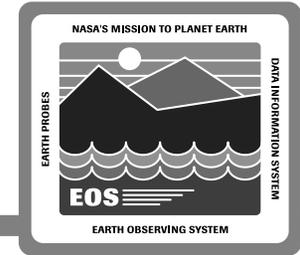
Command Uplink Scenario (cont.)



UPLINK PROCESSING:

- **“Controller” initiates processing of the command: (FcCmCCSDSFop)**
 - **CCSDS Frame is built (as FcCmTcFrame)**
 - CLTU is saved and queued (onto FcCmSentQueue)**
 - **Transmission of Frame is initiated (FcCmTcFrame)**
 - Frame is Transmitted (FcCmUplinkStream)**
 - CLTU sent to Ground Station for uplinking**
 - Restart of Timer initiated (FcCmTimer)**

Command Uplink Scenario (cont.)



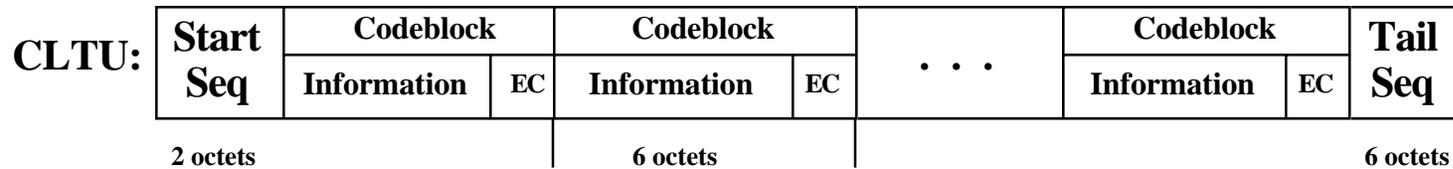
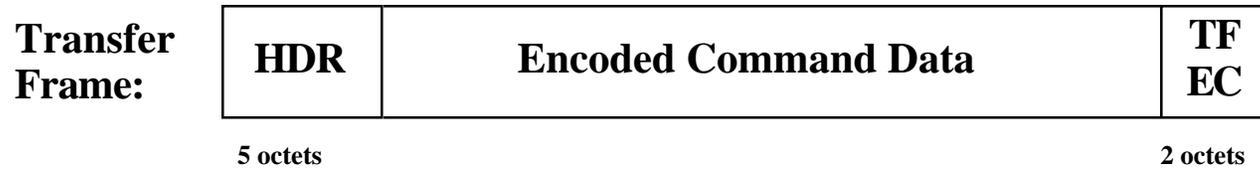
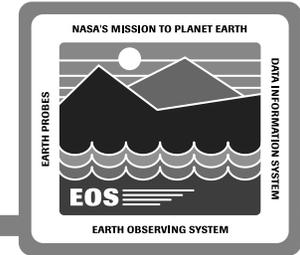
ACKNOWLEDGMENT PROCESSING:

ProcessClcw :

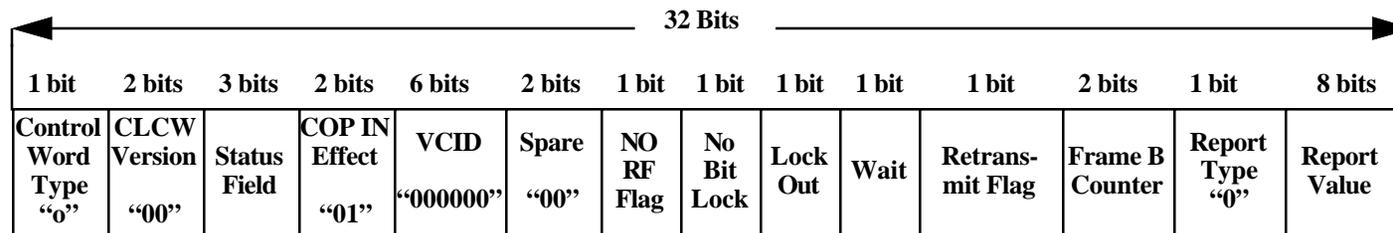
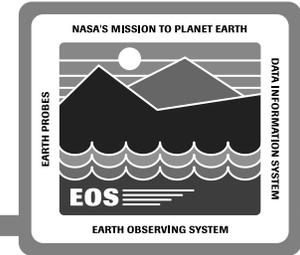
- Updates the Expected Acknowledgment Frame Sequence Number to the sequence number of the received CLCW
- Sets Transmit Counter to one
- Removes each acknowledged Frame from sent queue (via RemoveFrames - FcCmSentQueue)
- Receipt Status is set (FcCdRtCmd)
 - Sets the receipt status of the command that corresponds to the CLTU being removed
 - Command Status is forwarded to the “Controller”

User Interface is notified of successful receipt (FoGnCmdFuilF)

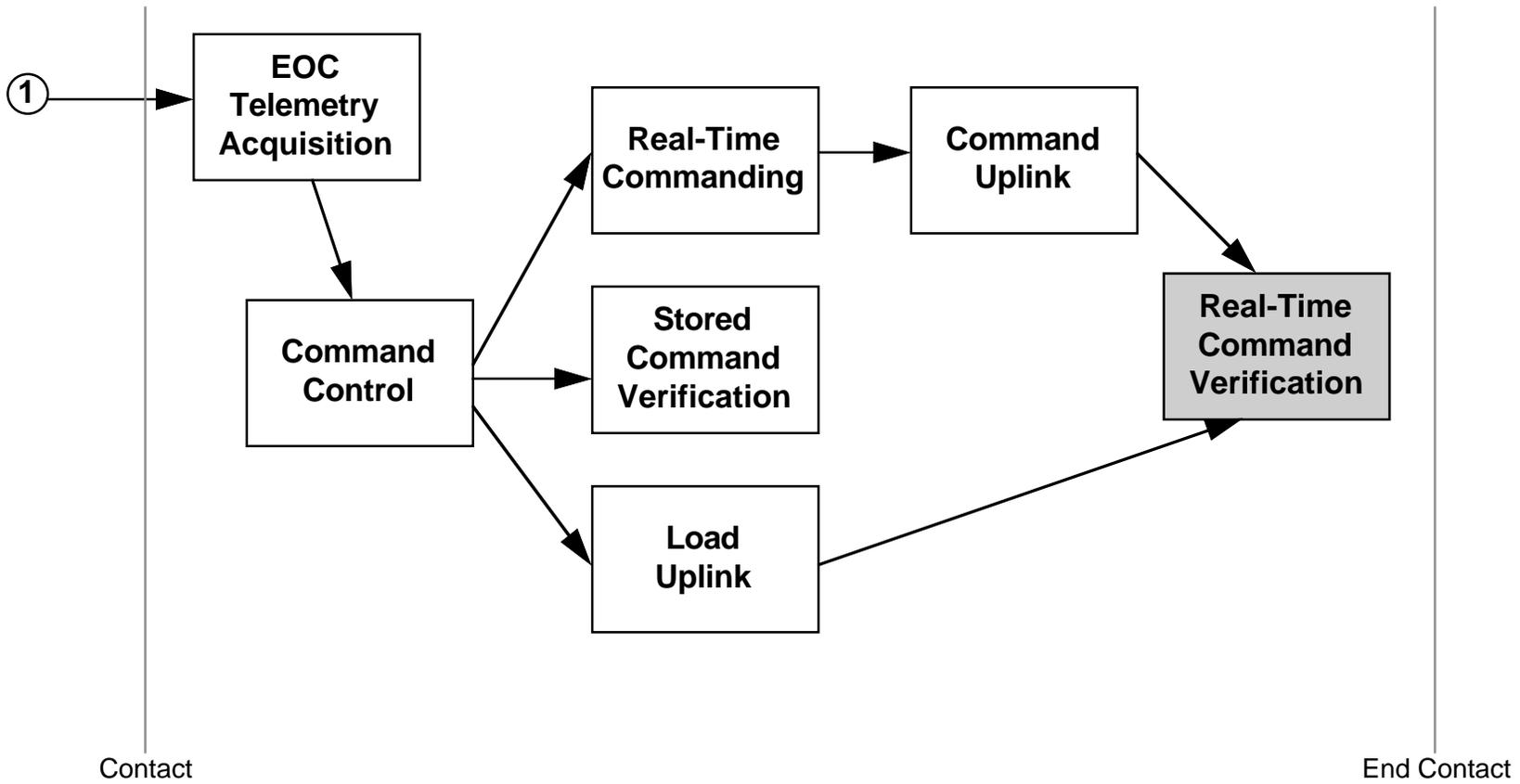
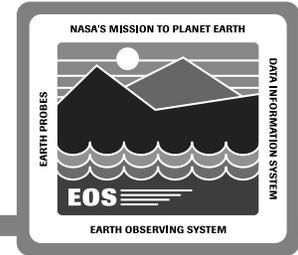
Uplink Cmd Data Transfer Formats



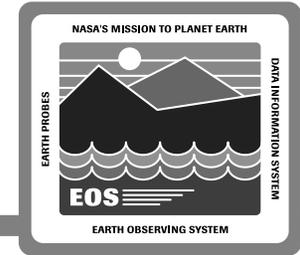
Command Link Control Word (CLCW)



Real-Time Command Verification



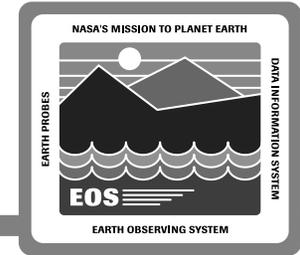
Real-Time Command Verification Description



Each command uplinked is represented by an individual object, which performs the verification (FcCdRtCmd)

Provides interfaces (User Interface and ASTER ICC) with status notification (FcCdRtCmdController)

Real-Time Command Verification Scenario



Upon completion of Uplink verification, Receipt Status is Set (FcCdRtCmd)

- **Timer is Set (FcCdCmd)**

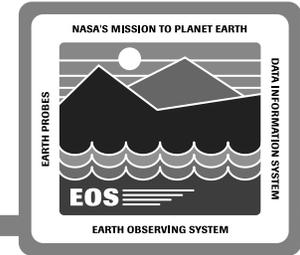
Telemetry Value is Checked upon expiration of timer; performs verification (FcCdCmd)

- **myExpectedTImValue is compared against actual telemetered value**

Command Status is forwarded to “Controller”

- **Uplink Status is Exported to ASTER ICC**
- **Uplink Status is forwarded to User Interface**

Real-Time Command Verification Design Benefits



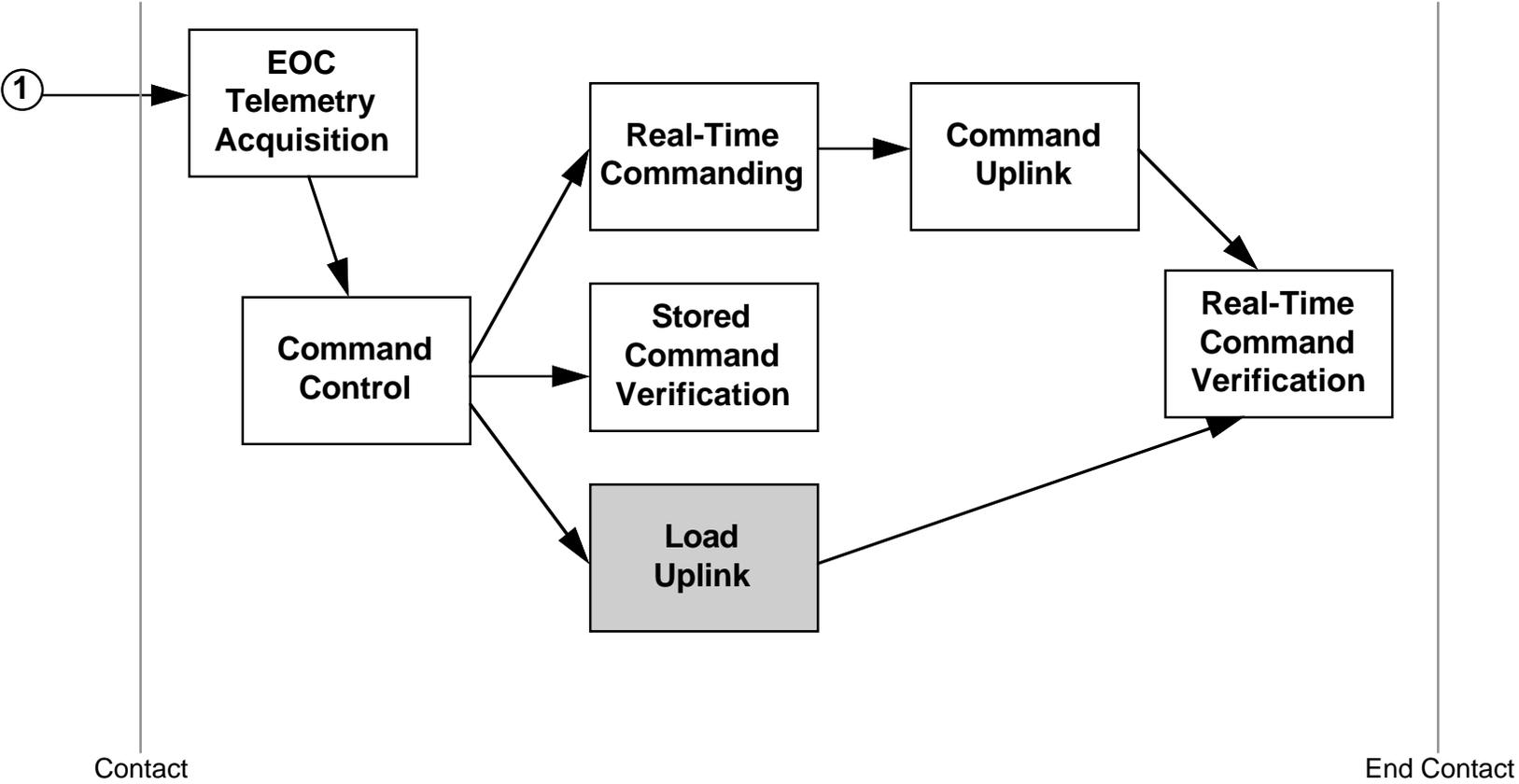
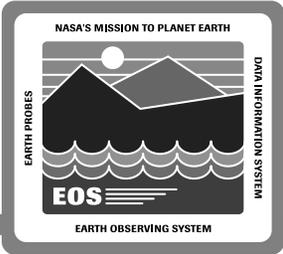
Command verification is ALWAYS implemented for those commands where it is defined

- **The enabling / disabling of CV only affects the ground script processing**

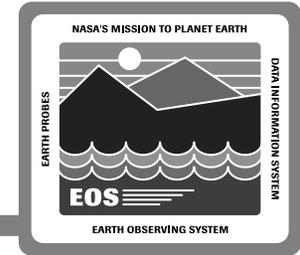
Execution timer is not set until AFTER uplink verification has been confirmed

- **Telemetry transmission delay time is already accounted for by virtue of the fact that the transmission delay for CLCWs is identical to that for telemetry**
- **Timer durations are NOT dependent upon transmission configurations**
 - **No calculations of duration are required during real-time processing**

Load Uplink



Load Uplink Description

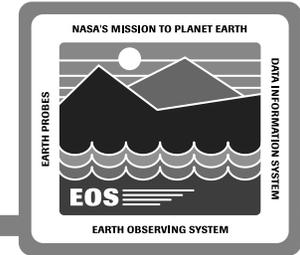


Handles spacecraft and instrument loads (FcCdLoadCmd)

- **Tables**
- **Software**
- **Commands**

Accesses load data for the specified load (FcCdLoadData)

Load Uplink Scenario



LOAD VALIDATION:

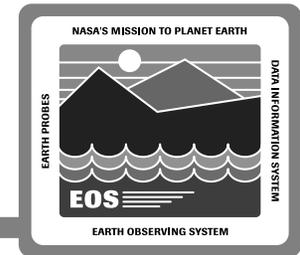
Load directive is forwarded by FOS User Interface subsystem

Checks for load command (determines that it IS a load command)

Initiates Validation (FcCdLoadCmd):

- **Compares ID of the issuer of directive against ID of Operator who has command authorization**
- **Verification of load command parameters (e.g. load id, destination, window) (FcCdLoadCmd)**
- **Checks ID of the issuer of the directive against valid users for that directive (FcCdLoadCmd)**
- **Issues a critical prompt for the Operator to respond allow or cancel**
 - **ONLY when the load contains critical commands**

Load Uplink Scenario (cont.)



LOAD GENERATION:

Initiates Building of the command (FcCdLoadCmd)

- Load data is fetched (FcCdLoadData)
- Load data provided, in CCSDS packet format

Initiates Processing of the Command (FcCmCCSDSFop - overloaded for both CCSDS packets & 1553-B commands)

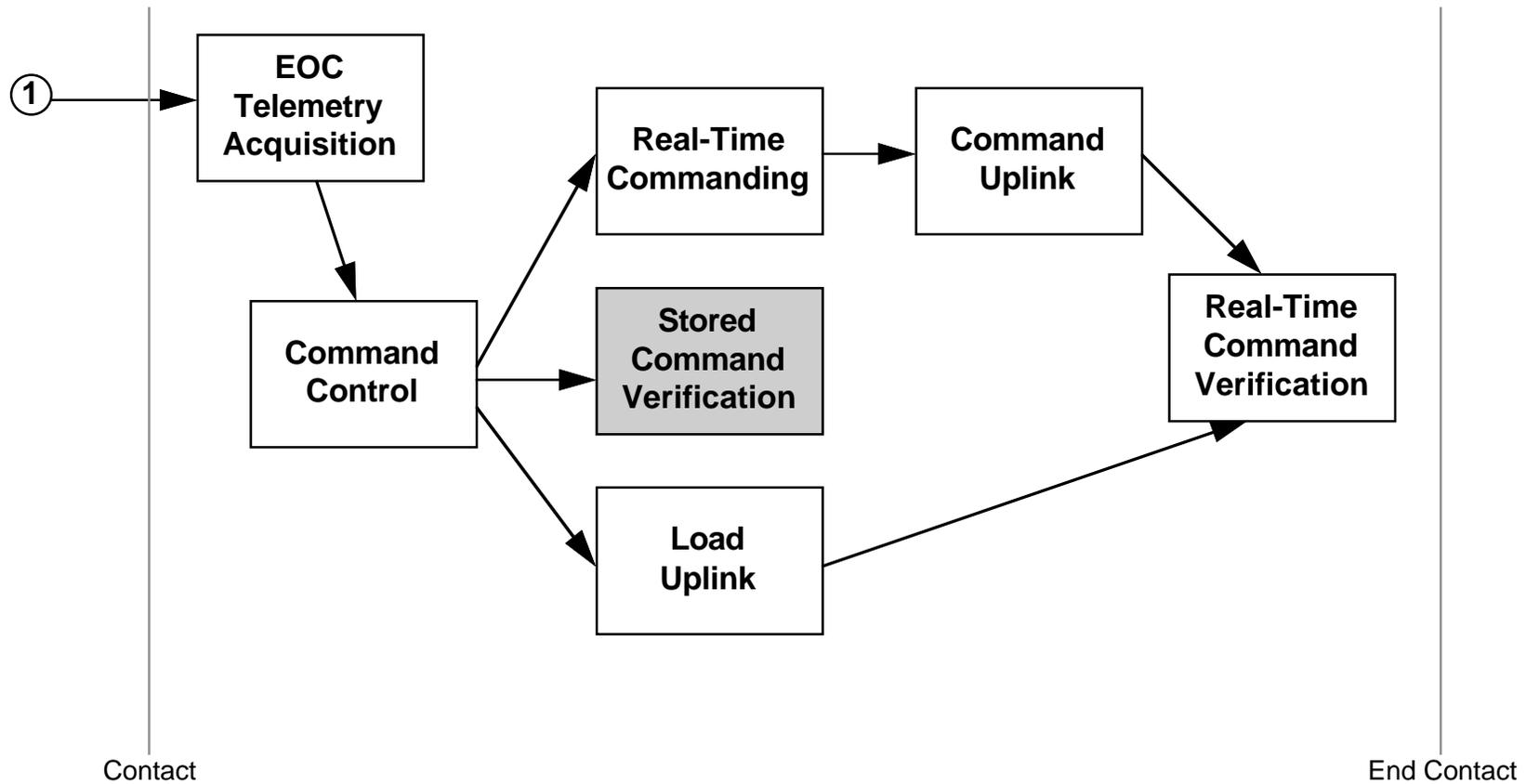
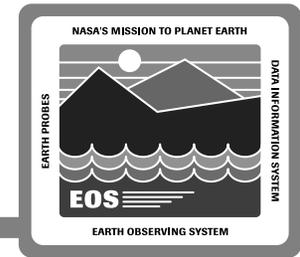
Process iterated until all load data uplinked

LOAD VERIFICATION:

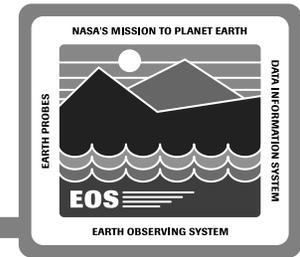
- Similar to real-time command verification
 - CRC status bit is the telemetered value to be checked
 - Additionally, command management is informed of load uplink status

allows for ground image to be updated

Stored Command Verification

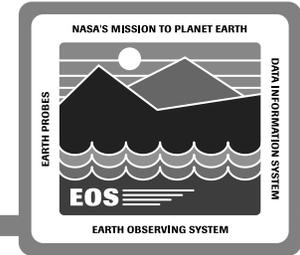


Stored Command Verification Description



Verification of the execution of a stored command (FcCdStoredCmd)
Coordination of the verification of stored commands with their execution onboard the spacecraft (FcCdStoredCmdController)

Stored Command Verification Scenario



**A directive to verify a stored command is forwarded by FOS User Interface
Compares ID of the issuer of the directive with ID of Operator who has
command authorization**

Access and retain verification information (within FcCdStoredCmd)

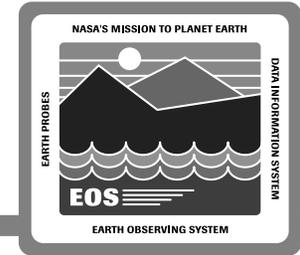
Timer is Set, specifying interval specific for the command (FcCdCmd)

Timer expires; telemetry value is checked (FcCdCmd)

Success status is forwarded to “Controller” (ReceiveCmdStatus)

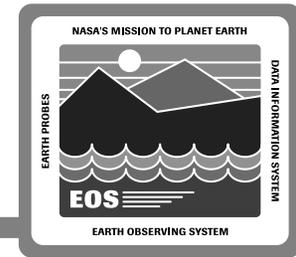
“Controller” forwards response status to User Interface

Stored Command Verification Design Benefits



Stored Command Verification gives users visibility into stored command processing during real-time contacts

Real-Time Scenario Post-Contact



Pre-Contact

- System Initialization
- User Connection
- Command Authority Request
- Ground Script Initialization
- NCC Communications Test
- EDOS Communications Test

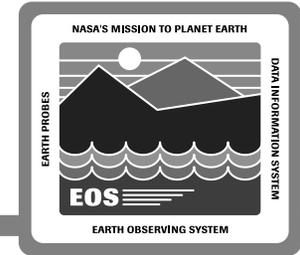
Contact

- Ground Telemetry Processing
- Spacecraft Telemetry Processing
- Spacecraft Commanding

Post-Contact

- Spacecraft Telemetry Playback
- Spacecraft Telemetry Merge
- Statistics Generation

Real-time Scenario Post-Contact Overview



Telemetry Playback

- Receipt of back-orbit telemetry from EDOS

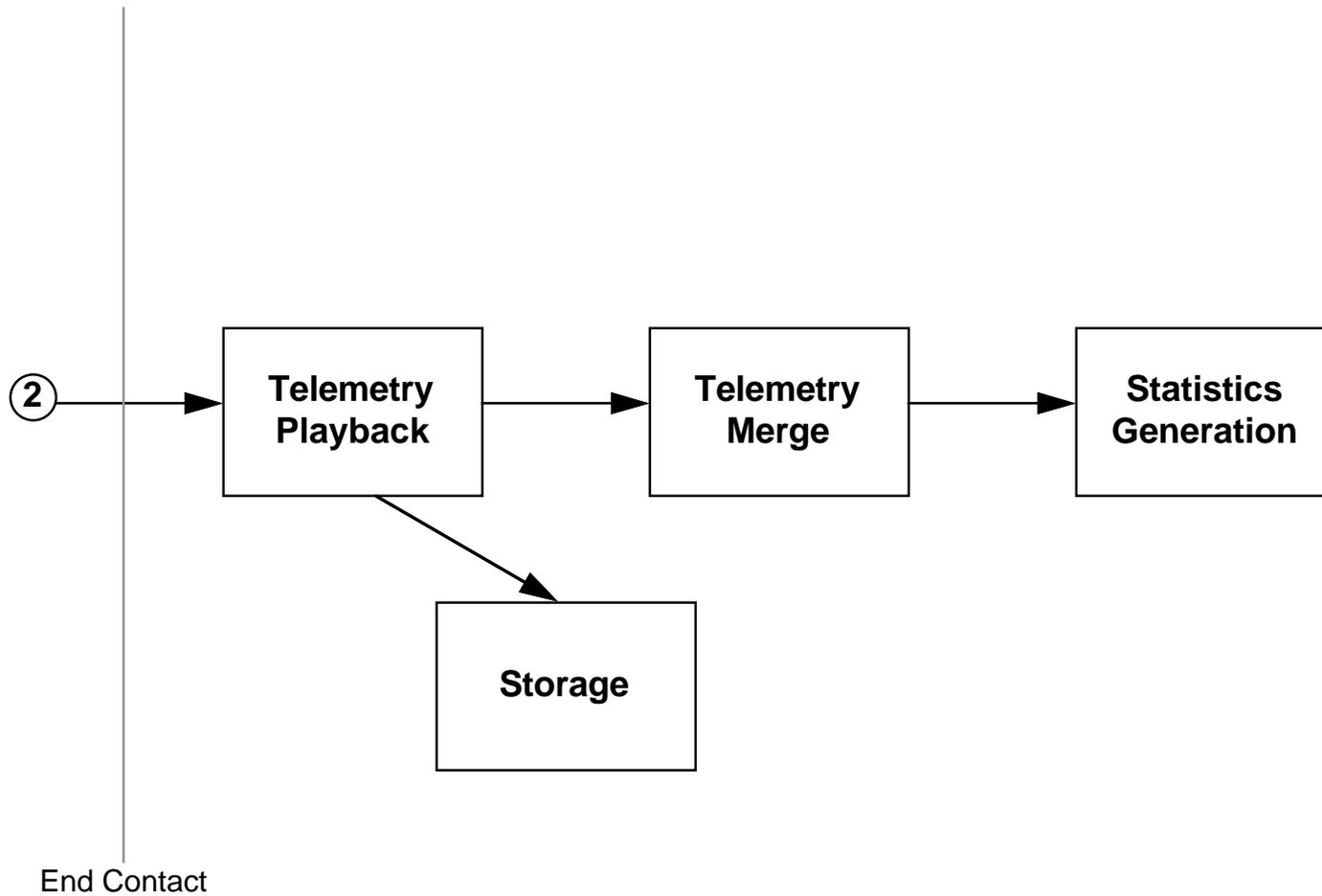
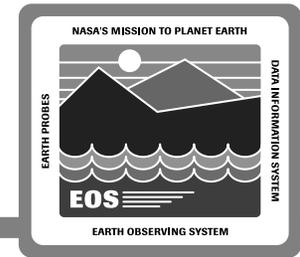
Telemetry Merge

- Merge back-orbit telemetry and real-time telemetry into a single seamless archive for each spacecraft

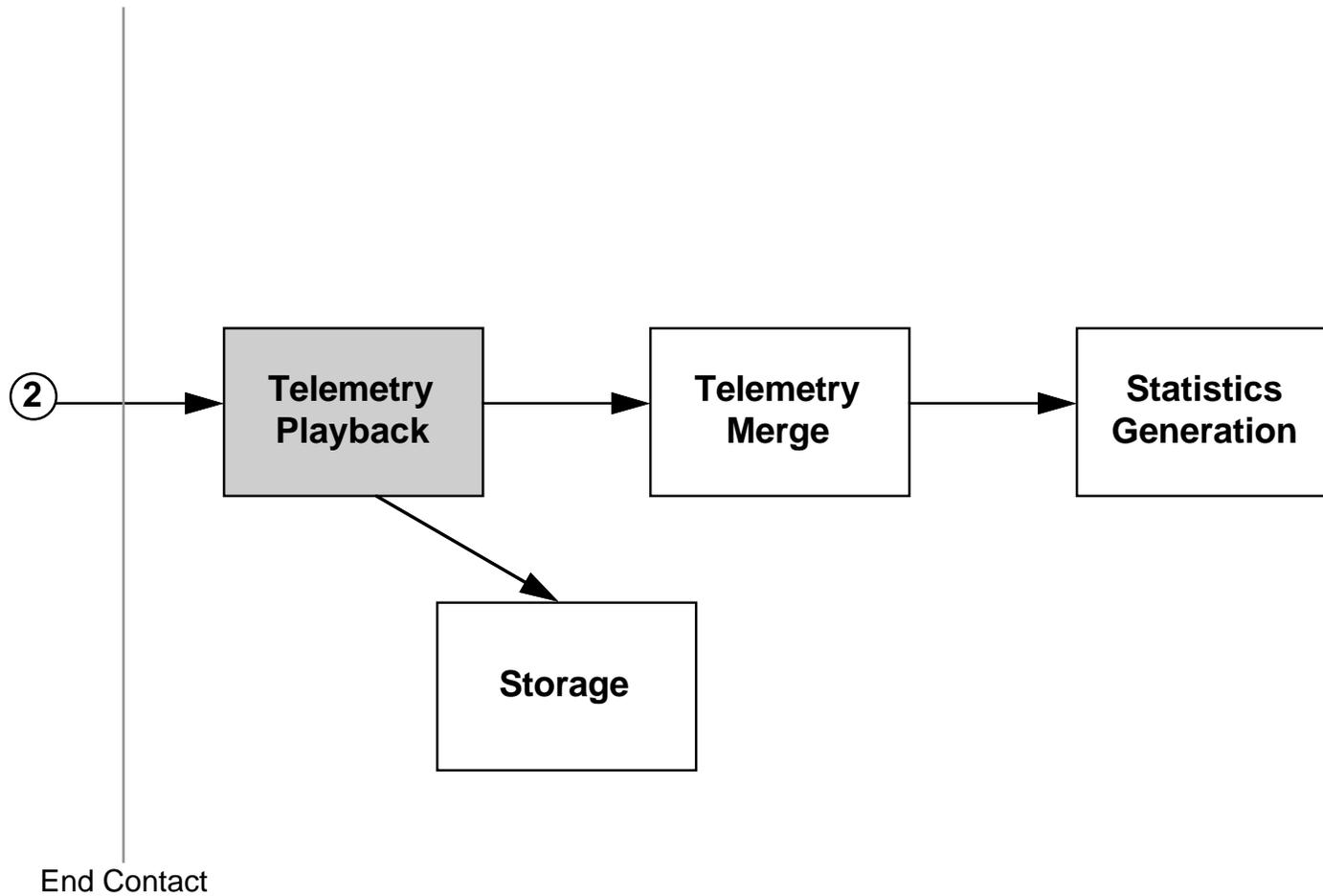
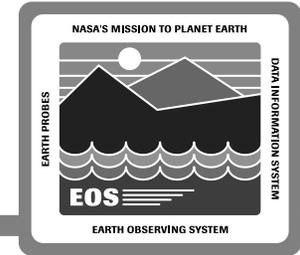
Statistics Generation

- Automatically calculate comprehensive telemetry statistics

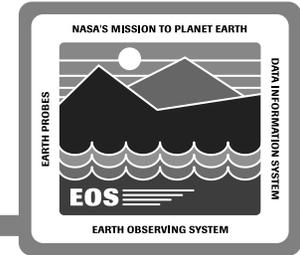
Real-Time Scenario Post-Contact



Telemetry Playback

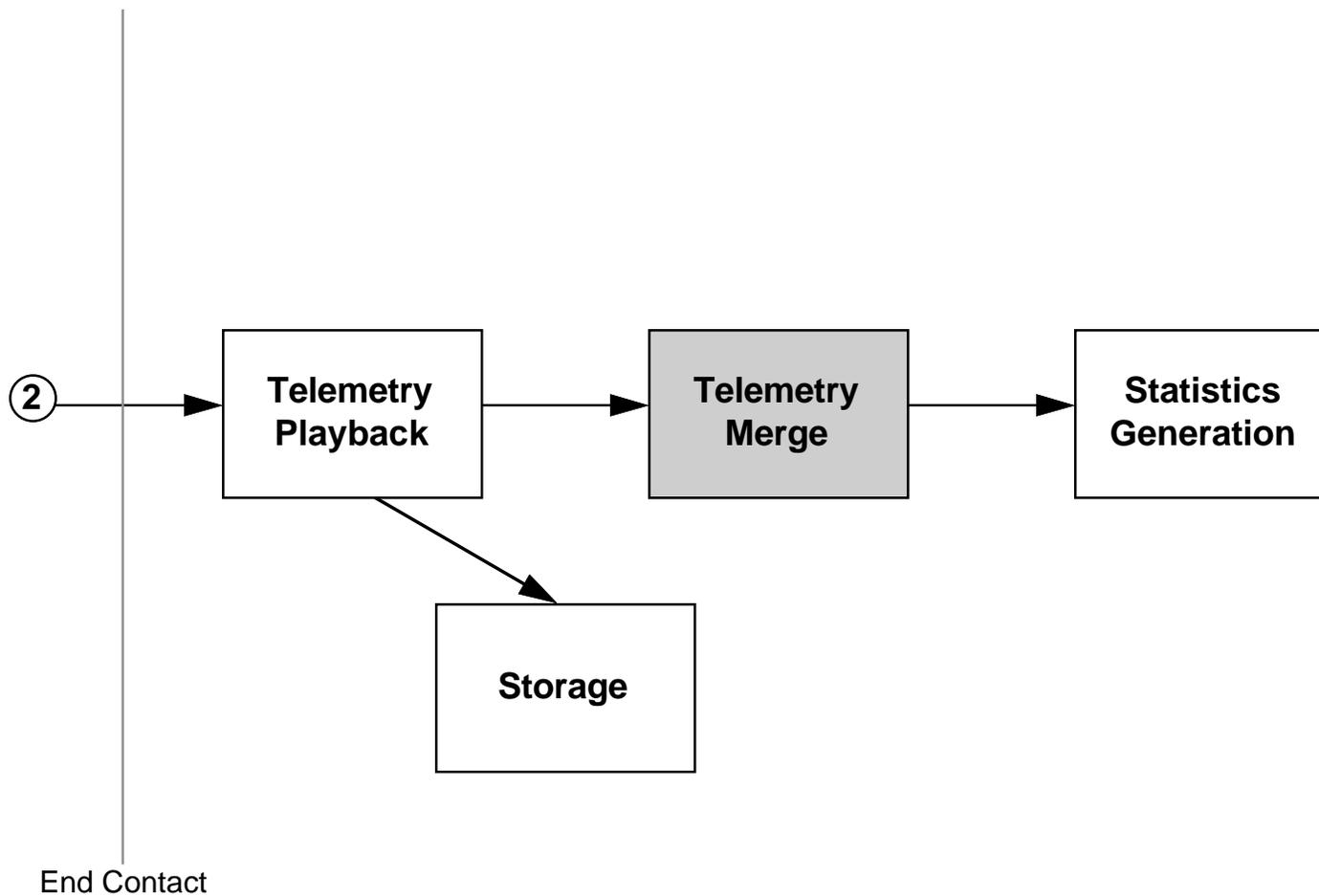
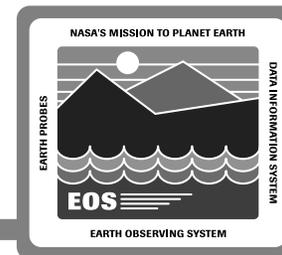


Telemetry Playback Description

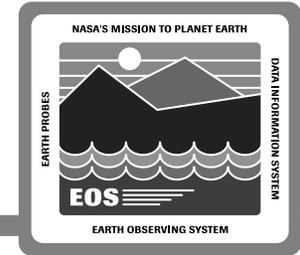


- **EDOS sends playback data to the EOC within 5 minutes from the end of contact with the spacecraft**
- **Playback data is provided via file transfer**
- **Incoming data will be stored in the format it was received**

Telemetry Merge



Telemetry Merge



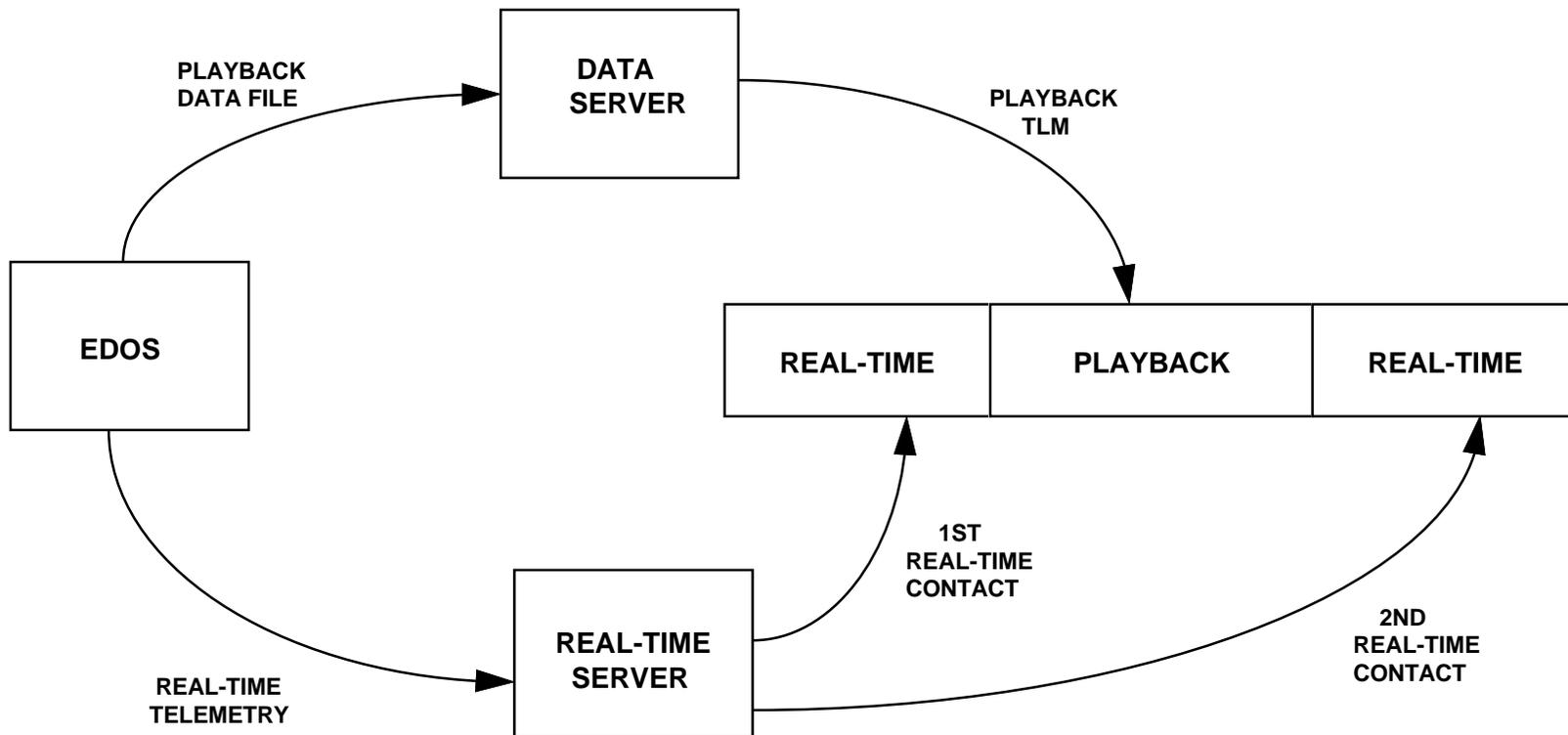
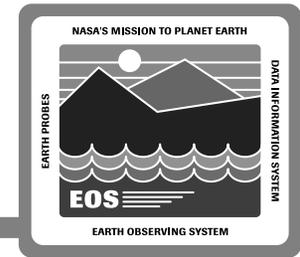
Playback data is merged with the archived real-time telemetry data to create a complete, contiguous, chronological and correct archive

- **Telemetry data is stored in hourly data files**
- **Duplicate telemetry packets are ignored unless existing packets are of poor quality**
- **Merge process is automatically initiated upon receipt of playback data at the EOC Data Server**

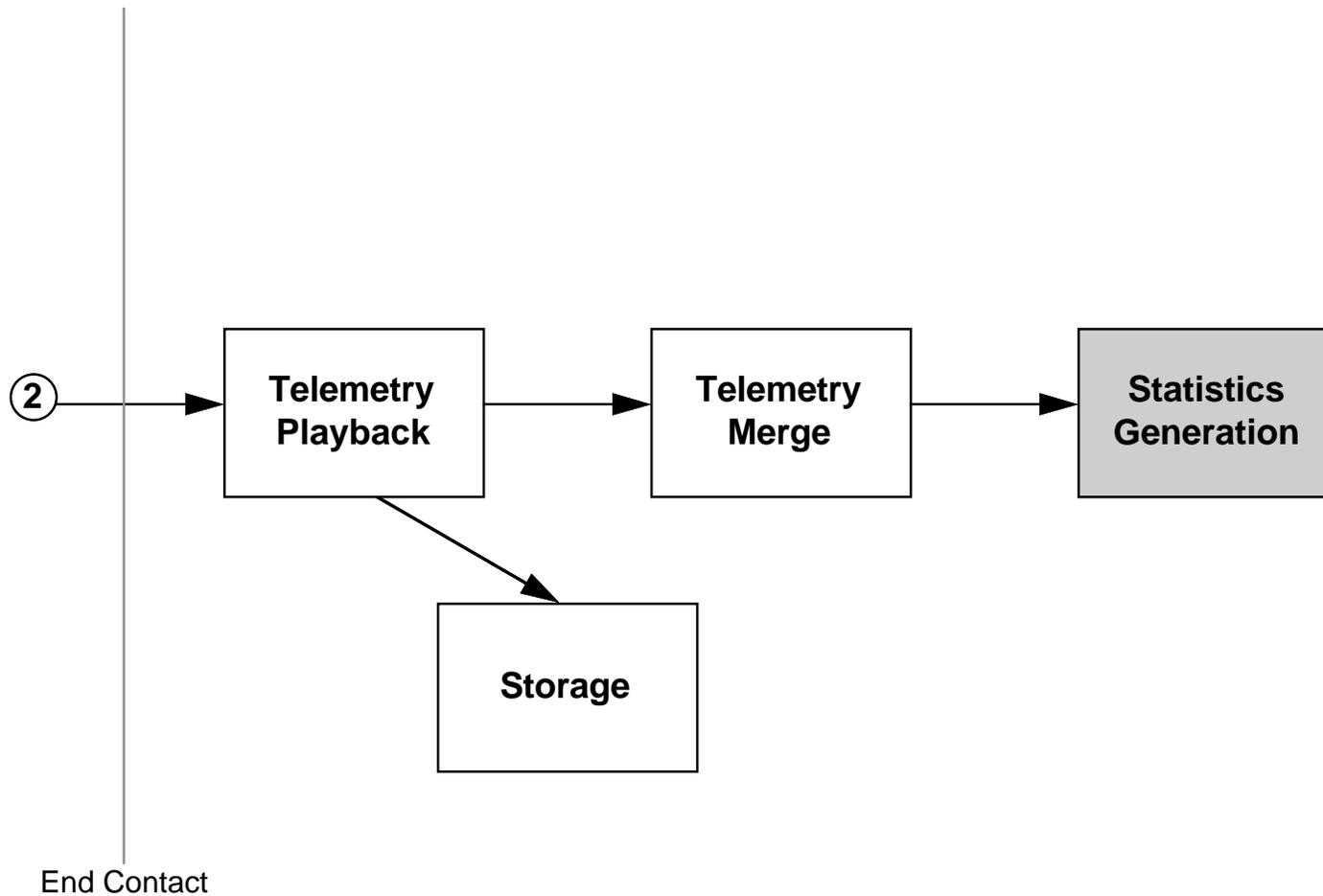
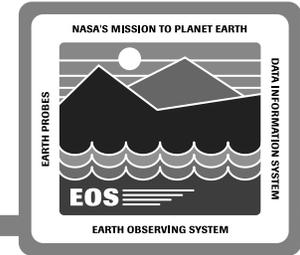
File information regarding the merged telemetry files is maintained in the data base

Merged telemetry files are sent to SDPS for long-term storage

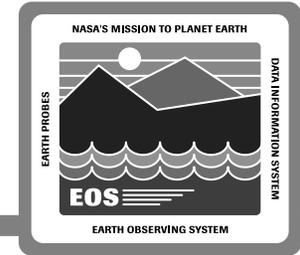
Telemetry Merge



Telemetry Statistics Generation



Telemetry Statistics Generations Description



DMS notifies Analysis upon completion of telemetry merge

Analysis coordinates with Resource Management to create a telemetry decom process

New statistics are computed based on the old statistics and new telemetry

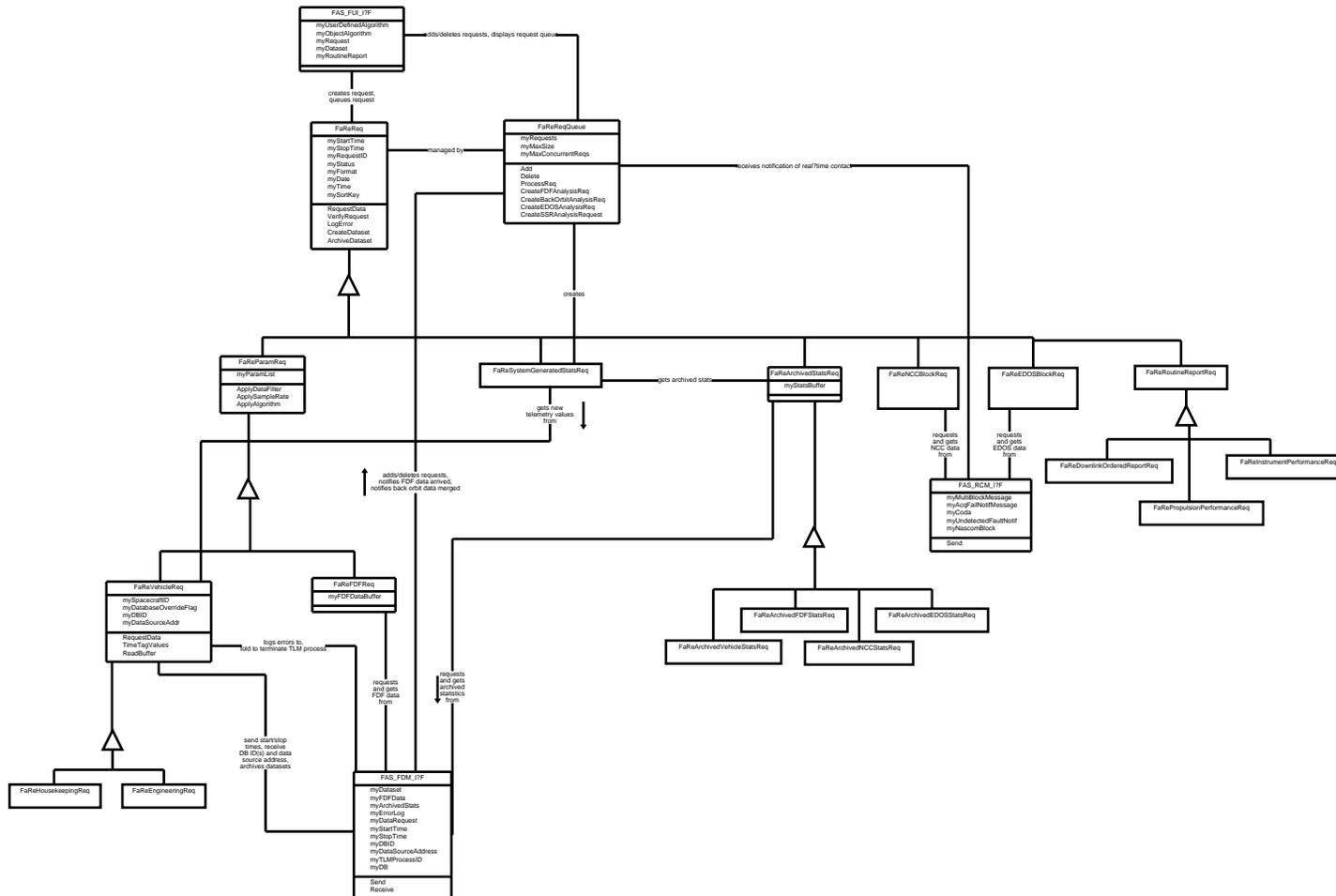
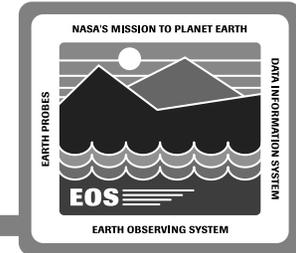
New statistics are stored at the DMS archive

Archived statistics are made available from the DMS

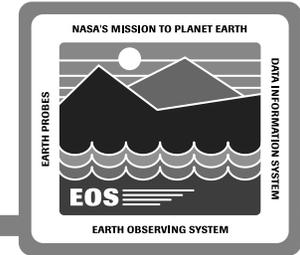
FOS maintains the following statistics for all parameters for each orbit, day, month and mission to date:

- **min, time**
- **max, time**
- **mean**
- **standard deviation**
- **number of samples**

Telemetry Statistics Generation



Post-Contact Benefits



Benefits:

- Merge process requires no operator intervention
- Statistics are automatically calculated when merge completes
- Statistics are immediately made available for use